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Resource Recovery

Final Report

FEASIBILITY OF RECOVERING ENERGY FROM MUNICIPAL WASTE IN THE TOWN OF LINDSAY

Ontario

Ministry of the Environment
Ministry of Energy

Spantec Limited
in association with
Underwood McLellan (1977) Ltd.

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SOURCE TECHNOLOGY
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Final Report

FEASIBILITY OF RECOVERING ENERGY FROM MUNICIPAL WASTE IN THE TOWN OF LINDSAY

Spantec Limited

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Peat, Marwick and Partners

Resource Technology Corporation

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SUMMARY

This study has

- quantified the garbage generated in Lindsay, both at present and as a range of possibilities in the future. The tonnage of garbage is converted to an equivalent energy content. The seasonal pattern is established.
- appraised existing technologies for converting garbage into a usable form of energy.
- surveyed the markets for the energy that would be produced by the alternative technologies.
- selected one technology (steam generation) as being the most suitable for Lindsay, given the technological factors, and the match of energy supply and demand in the marketplace.
- proposed alternative workable schemes, each consisting of an identified steam user and a site suitable for constructing a plant to receive garbage and generate steam, and recommended one.
- carried out a conceptual design of an appropriately sized plant, and costed it.
- forecasted the financial performance of the scheme, and measured the sensitivity of the financial performance to ranges of assumptions for energy prices, garbage generation, and write-off periods.

The financial analysis shows that even with the revenue from the sale of steam, the scheme is likely to lose money (to a greater or lesser extent, depending on the assumptions made) compared with the alternative of dumping raw garbage on a landfill site. Put another way, this loss is the price that society has to pay if it wants to dispose of its garbage other than by burying it in the ground.

Most of the risk lies in the uncertainty about future garbage supplies. If the market for waste paper/cardboard for recycling purposes becomes strong and permanent, the scheme loses both a good source of energy and a source of tipping fees; on both counts the losses increase. Risk also arises from uncertainty about the level of future energy prices. Thus the financial risk is greatly influenced by a future state of affairs which is outside

the control of the Town.

The Town of Lindsay has submitted a request to the Province of Ontario (through the Ministry of the Environment) for financial assistance. This report is therefore orientated to describing how much assistance by the Province would be required, assuming the Province takes all of the risk. The Province has stated that its policy is to provide one-time financing, rather than an on-going subsidization of losses every year. Assistance might, therefore, take the form of a one-time grant to the Town of Lindsay which will be large enough to fund the stream of losses assuming the worst happens; at the end of an agreed period(s), there will be an accounting of what has happened and the Town would refund to the Province the excess by which actual performance exceeds the worst case.

In addition to funding the losses, the funding of the cost of constructing the plant has to be secured. It is probable that agreements can be devised which will limit the total up-front cash demands to the greater of

a) the grant to cover losses, and
b) the construction cost,

rather than requiring cash to cover both. Cash required in excess of the losses is to be repaid, notionally, by the tipping fees that would still be collected but would no longer be needed to operate the landfill site. The amount of the grant has been estimated at $1.5 million approximately, plus a refundable contribution to construction costs, but is subject to further refinement. In particular, it will not be finally known until

- the operator of the steam plant and his operating relationship with the steam user are decided. This will affect the type and cost of the instrumentation and controls that have to be provided.
- the plant is tendered.
- the terms of the agreements (including interest rates) between the Province and the Town and between the Town and the steam user are finalized.

Consequently, it is recommended that there should be a further stage of study whose goal is final definition of Provincial involvement, signing of the above agreements, and the start of construction. During this stage, the following activities will take place:

- the operator of the plant will apply for an Environmental Assessment hearing, and obtain approval to construct the plant.
- final engineering of the plant, including instrumentation and controls and tie-ins to the steam user, will be done. Tenders for the construction of the plant will be called.
- the terms of the above agreements will be negotiated and finalized.

It is recommended that terms of reference for this Stage II are drawn up, and that funding for it be provided.

CHAPTER 1 - HOW MUCH GARBAGE IS THERE?

1.1 CLASSIFICATION AND CURRENT TONNAGES

For the purposes of this study, the waste that Lindsay has to dispose of was classified in four categories:

1. Residential collection (regarded as combustible).
2. Miscellaneous industrial and commercial collection (regarded as combustible).
3. Waste delivered by specific industries (regarded as combustible).
4. Construction waste (regarded as non-combustible).

Because of the tight schedule allotted for the study, it was not possible to collect data on quantities of wastes over more than a short period. Actual measurements of all the above categories were made for the weeks ending December 3, 10, and 17, 1977; monthly generation rates were extrapolated from these records and from the Town's drop charge records (which apply to non-residential waste).

Waste generation was verified by the installation of a weighbridge by the Town of Lindsay and the measurements obtained for the weeks ending December 3, 10 and 17, 1977 are summarized in Exhibit 1. (The detailed results appear in Appendix 1.)

For the three weeks, an average of 257.6 tons of waste other than construction waste was delivered to the landfill site. This average was composed of 61.2 tons of wastes from the Town's residential collection, 97.0 tons of miscellaneous industrial/commercial wastes collected under contract by private hauler, 88.0 tons of wastes delivered by major industries and an estimated 11.4 tons of wastes delivered by miscellaneous small trucks and cars. This latter figure was based on an average 150 lbs. per load and was composed largely of residential wastes.

Data on annual generation rate on a weekly basis is quite limited. However, based on a review of this data and conversations with the Town's collection contractor, a typical curve has been plotted to indicate the expected

Exhibit 1

QUANTITIES OF SOLID WASTES DELIVERED TO LANDFILL SITE
NOV. 28 - DEC. 17/77 SUMMARY

(Weighbridge Measures - In Tons)

ORIGIN	TYPE OF WASTE	TOTAL 3 Wks.	AVG. PER WEEK	HIGHEST DAY
Residential (Incl. Misc. Cars, Trucks)	Residential	217.95	72.65	21.66
Misc. Industrial/Commercial (Town)	Mixed (At least 50% paper & cardboard)	290.86	96.95	30.90
Specific Industrial				
Abex	Cardboard & brake Linings (Asbestos)	39.01	13.0	
Armstrong	Cardboard & Carpet	33.88	11.29	
Canada Crayon	Cardboard & Wax	13.41	4.47	
Deyell	Baled Paper	35.08	11.69	
Lindsay Paper Box	Paper	7.91	2.64	
Loblaws	Cardboard	13.37	4.46	
Prowler	Wood, Paper	44.53	14.84	
Rosedale Plastics	Plastic & Cardboard	.91	.30	
Trent Rubber	Rubber & Cardboard	17.52	5.84	
Union Carbide	Cardboard, Polyethylene film & cellulose	53.05	17.68	
Uniroyal	Cardboard & Refuse	5.44	1.81	
Sub-total: Specific Industrial		264.07	88.02	30.12
TOTAL (Combustible)		772.91	257.60	72.15
Construction Waste		43.85	14.62	15.01
TOTAL (ALL)		816.76	272.22	-

Exhibit 2

RESIDENTIAL SOLID WASTES
ESTIMATED GENERATION RATE 1977
(TONS/WEEK)

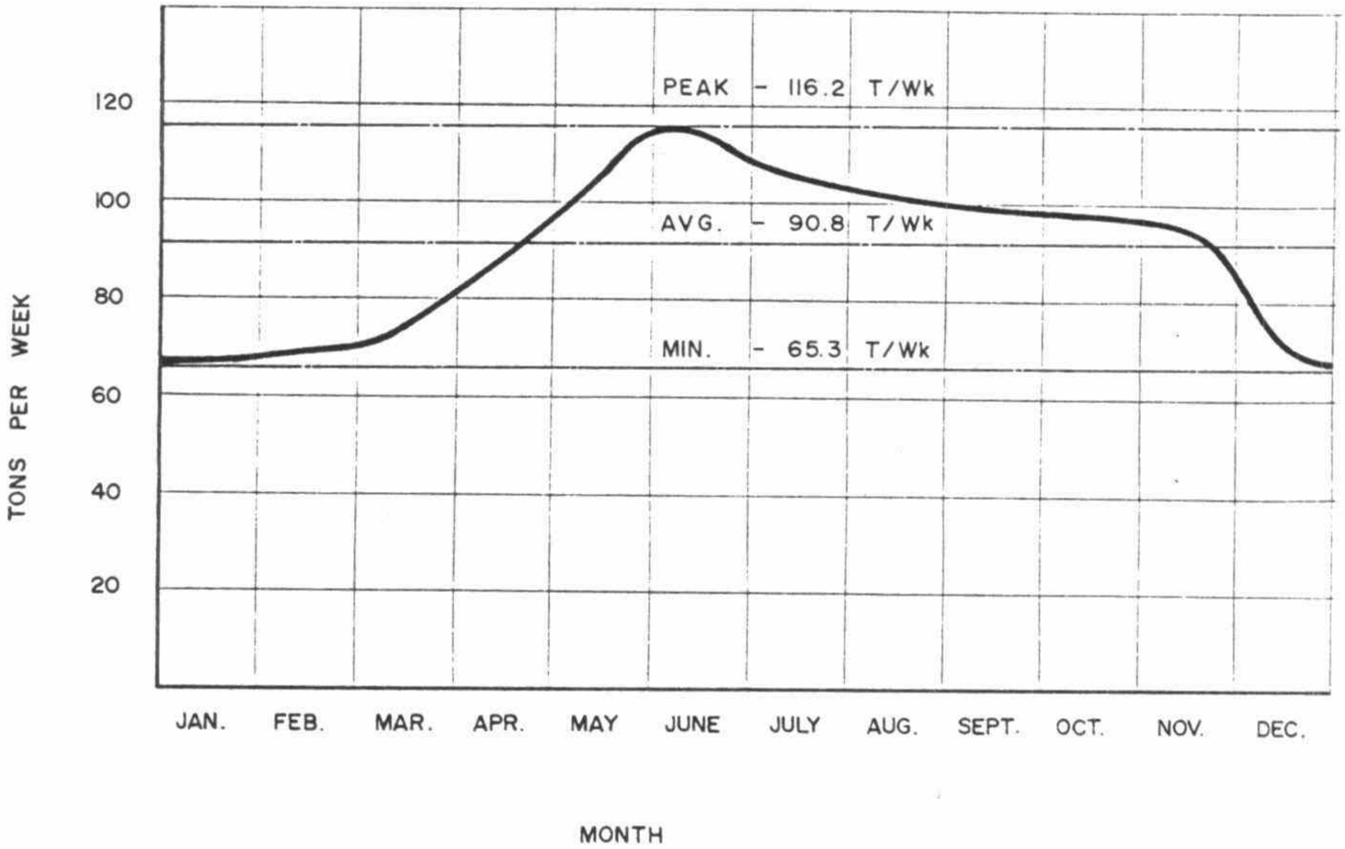
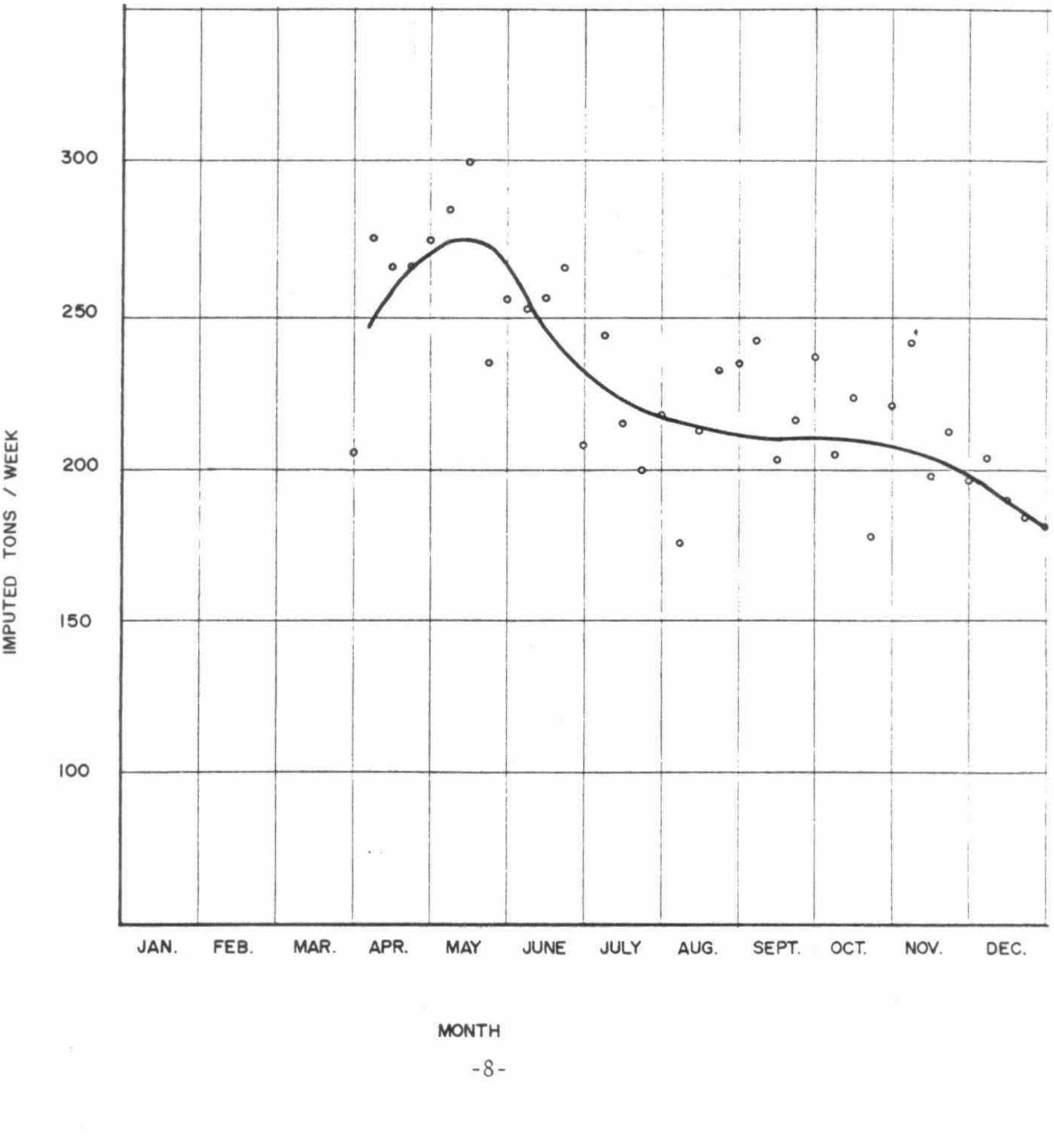


Exhibit 3

IMPUTED GENERATION OF INDUSTRIAL AND COMMERCIAL REFUSE 1977



monthly generation rate for Lindsay. This curve is similar to current conditions in Windsor. An allowance has been made for the transient summer population which suggests a peak generation during the summer. Minimum winter generation normally occurs early in January and is probably of the order of 10% less than the average of the three weeks studied. Such a curve of weekly generation is given on Exhibit 2. From inspection, the average generation rate would be approximately 25% greater than the average of the three weeks studied.

Dumping of industrial and commercial wastes taken to Lindsay's landfill site is charged on a truck volume basis. Charges levied for the weeks ending April 9 - December 7, 1977 are recorded on Appendix II. Comparison of average tonnage (185) with average revenue ($1,150) for the three weeks studied yields an average charge of $6.22 per ton for dumping. Applying this average to the other weeks' revenues gives the imputed tonnages recorded on Exhibit 3.

The curves of Exhibit 2 (residential) and Exhibit 3 (industrial and commercial) are sufficiently similar to suggest that a reasonable approximation would be to use the same factors to arrive at minimum, maximum and average weekly tonnages. The calculation is shown on Exhibit 4 and yields the following figures for 1977:-

231.8 tons per week of combustible wastes as a probable minimum.

412.2 tons per week of combustible wastes as a probable maximum.

322.1 tons per week of combustible wastes as a probable average.

Including an allowance for construction wastes, solid wastes taken to the landfill site in 1977 would thus be estimated at 52 weeks at 336.7 tons per week average, or close to 17,500 tons per year.

This total is very close to 6 lbs./day for the 16,000 population of Lindsay and the Township of Ops. This is high by comparison with other centres, but would be explained by the presence of specific industries with high waste generation, tourist and student additions to the population in summer, and a commercial market area well beyond the Town and Township boundaries.

1.2 FUTURE PATTERNS

In assessing the future patterns of wastes, recognition of likely changes in the specific industries' deliveries must be made. These wastes are largely paper and wood, with a high heat value and, at times, have attractive material recovery values. Industries such as John Deyell (Printers) and Prowler Industries (trailer manufacturers), who together provided close to one third of the specific industrial deliveries to the landfill site recorded in the three weeks studied, are known to have considered, or used, other means of disposal than the Town landfill. Such reduction in waste deliveries would not only significantly reduce the available heat energy, but also the revenue from dumping charges.

Analyses in this report will thus be based on two scenarios: 'Optimistic', which presumes that 1977 estimated waste tonnages can be used as the basis for estimating available energy, and 'Pessimistic', which presumes that only 50% of the specific industrial deliveries can be relied on.

Each scenario is projected into the future by applying a growth factor.

Population growth for Lindsay is assumed at 1¼% per annum compound or 6% over 5 years and 28% over 20 years. Current trends suggest that per capita generation of wastes may have levelled off after several years of rapid increase. It is thus proposed that the future quantity of waste is estimated by taking 1977 quantities (either "optimistic' or 'pessimistic') and applying a growth factor of 1¼% per annum compound.

Exhibit 4

ESTIMATED QUANTITIES OF SOLID WASTES GENERATED (1977)

ORIGIN	AVERAGE TONS PER WEEK	FACTORS ASSUMED			ESTIMATED TOTALS TONS PER WEEK		
	NOV. 28- DEC.17/77	MIN.	MAX.	AVG.	MIN.	MAX.	AVG.
Residential Collection (Incl. Misc. Cars, Trucks)	72.6	.90	1.60	1.25	65.3	116.2	90.8
Misc. Industrial/Commercial Collection	97.0	.90	1.60	1.25	87.3	155.2	121.3
Specific Industrial Deliveries	88.0	.90	1.60	1.25	79.2	140.8	110.0
SUB-TOTAL (Combustible)	257.6				231.8	412.2	322.1
Construction Waste	14.6	1.0	1.0	1.0	14.6	14.6	14.6
TOTAL (ALL)	272.2				246.4	426.8	336.7

CHAPTER 2 - WHAT CAN BE DONE WITH IT?

Discussion in this chapter of the report focusses on three issues. First, what scope is there for improvement by sorting wastes at their source, and providing separate collection and disposal methods? Second, what technology is available for processing waste in different ways? Third, is there any market in Lindsay for the output of processed waste?

2.1 ASSESSMENT OF SOURCE SEPARATION IMPACT

In assessing the impact of separate collection of such materials as cans, bottles and newspapers on any energy recovery system for the Town of Lindsay, it is most important to evaluate industrial and commercial wastes separately from household wastes.

The industrial and commercial wastes delivered to the current landfill operation in the Town of Lindsay can be characterized as being predominantly paper and cardboard which, although it has a comparatively high heating value, also represents potential feedstock for use as secondary paper for remanufacture or other industrial uses. In most instances, the paper products from the various industrial and commercial establishments could be segregated to some extent at the source and prepared for sale in the secondary paper industry, should the current market value for such paper products justify this approach. In the event that the commercial and industrial establishments in the Town of Lindsay elected to practise a form of source separation and paper recycling (whether for economic or social reasons), the impact upon the energy recovery concept under consideration would be profound.

While it is difficult to assess the probabilities of such an occurrence in the future in the Town of Lindsay, the potential impact should be recognized in the 'Optimistic' and 'Pessimistic' scenario alternatives. While local legislation can direct the flow of wastes to a particular location, it is unlikely that such legislation could force industries to continue producing waste materials indefinitely if they elected to divert a portion of the stream which had historically been wasted for recycling into other products.

In addressing household waste, a number of alternative scenarios of varying degrees of source separation can be conceived. In general, household wastes contain the majority of the potentially recyclable cans, bottles and newspapers which are found in the total waste stream of the community. Three scenarios were identified for investigation which represent the major alternatives available for source separation. They are:

- no source separation of household waste.
- source separation of newsprint only.
- source separation of household wastes into "burnable" and "non-burnable" fractions.

Each of these scenarios was assessed to determine the impact on the energy recovery system economics, potential environmental impact, and potential social or public relations impact.

2.1.1 Scenario 1 - No Source Separation

In this scenario, all citizens would continue to aggregate all their household wastes into single containers for collection and disposal by the Town of Lindsay. In this event, the solid waste collection costs of the Town would be minimized and the maximum potential energy recovery revenue would be realized since all of the household wastes would be delivered to the energy recovery facility. On the other hand, this scenario would provide minimum public participation in the Town's resource recovery program and this might be considered to have some level of negative social impact on the overall waste management strategy.

2.1.2 Scenario 2 - Source Separation of Newsprint Only

In this scenario, it is assumed that individual householders would segregate the newspapers from the rest of their solid wastes, bundle them periodically and deposit them adjacent to the waste containers for collections by the Town's vehicles. Further, it is assumed that the refuse collection vehicles would be fitted with low-cost racks attached to the vehicle for the purpose of transporting the bundled newspapers to a central point without the possibility of them becoming contaminated by other items in the solid waste. In this situation, the resource recovery facility would have the option to make discrete market selections, dependent upon the current market value of secondary paper fibre, insulation, and fuel. If it were in the Town's best interests to do so, these segregated newspapers would be recycled into a number of alternative markets or could be processed along with the rest of the wastes for energy recovery. Further, the public relations value of such citizen participation is generally acknowledged to be a positive social impact. On the other hand, this situation could lead to a reduction in the steam or fuel revenue accruing to the resource recovery facility in the event that paper recycling options were exercised by the Town. Also, previous attempts at other locations have not proved to be successful in the long run.

2.1.3 Scenario 3 - Source Separation of "Burnables" Versus "Non-Burnables"

In this scenario, it is assumed that individual householders would segregate the metal and glass materials from their solid wastes and package these separately from the organic paper and plastic fractions of household refuse. (This concept was used historically in some locations in the United States with some degree of success although public interest waned after some period of time.) In this concept the collection costs for household refuse would increase somewhat for the Town of Lindsay, since arrangements would have to be made for separate pickups of the two fractions which were segregated in the household. Very likely this economic impact could be ameliorated since the "non-burnables" fraction of household waste represents a comparatively low volume of the refuse material and generally does not tend to have significant quantities of putrescribles associated with them. Thus, in many cases the material could be safely stored at the household for a period of some weeks without constituting a fire hazard or a vector problem and could be collected perhaps on a monthly or bi-monthly basis. In this event, the increased collection costs could be minimized.

The advantages of this system are that the fuel product from refuse is optimized and the inerts, being largely removed from the waste stream, do not detract from the extraction of the energy value of the refuse. In addition, the non-burnable fraction could be segregated rather easily into its various components at the resource recovery facility. The segregation by product could be done manually, if it were deemed socially advantageous to provide additional jobs. Alternatively, a relatively rudimentary mechanical system could be devised for segregating the ferrous metals, the nonferrous metals, and the glass products for subsequent recycling and resale.

2.1.4 Conclusions on Source Separation

It can be seen that, depending on a number of conditions, source separation could significantly affect the economic feasibility of resource recovery for the Town of Lindsay. On the other hand, there are varying scenarios which would tend to minimize the adverse environmental and economic impacts and, in some cases, tend to optimize the resource recovery concept.

It would appear that no specific action can be recommended at this time with respect to source separation. Provision should, however, be made for receiving separated newsprint from residential collection at the energy recovery plant and efforts should be made to continue the current flow of industrial and commercial wastes.

2.2 WHAT TECHNOLOGY IS AVAILABLE?

Within the last ten years in large cities, solid waste processing technology has evolved from a basic collection-haul-landfill or collection-haul-incineration cycle, to a rather large, and sometimes confusing array of processing techniques. These advanced technology processes, subsystems, or systems are designed to subject the solid waste stream to collection, shredding, air classification, screening, electromagnetic, heavy media and optical sorting, with final utilization of the cellulosic fraction for such processes as composting, fuel supplements, pyrolysis or bioconversion. Obviously all of these unit processes would not apply equally to the Town of Lindsay because of the relatively small amount of garbage available for processing, and the resultant economic sensitivity. Therefore, the various alternatives were evaluated and four major processing candidates were identified. These are:

- Preparation of a product known as Refuse-Derived Fuel, or RDF.
- Package steam boiler systems, with the possible addition of turbine-

driven electrical generators.

- Pyrolysis systems.
- Scaled-down waterwall incinerators or equivalent.

Obviously in each of these concepts discussed in the following pages, there are certain common denominators. For example, each type of facility would require a receiving area and material handling equipment to move the material from the receiving area to the final point of use. In addition, some separation (certainly of the higher value products in the waste stream) is desirable. Thus, technology assessment for a solid waste system involves principally concepts of material handling and material separation. Material separation usually favours handling the largest fraction first and then progressively working down through the next largest fractions, leaving the smallest amount of unmarketable material possible for eventual landfill. It should be recognized that regardless of the type of process chosen, there will be a requirement for some landfill since there are always process residues.

2.2.1 Refuse-Derived Fuel (RDF)

Principal processes involved in the preparation of refuse-derived fuel are receiving, shredding, and air classification. In air classification, the solid waste stream, which has been homogenized by shredding, is split into two principal fractions pneumatically, by a rising current of air. The materials which are too heavy to fly, or the so-called drop fraction, usually amount to 15-25% of the solid waste stream, depending on the air classifier selected. The light fraction, which therefore consists of 75-85% of the waste stream, is the product usually referred to in the industry as "refuse-derived fuel". This fraction is not particularly maladorous. This fuel fraction also includes a significant percentage of dust, dirt, and occasional fine glass which will leak from almost any crack or opening around conveyors or valves or will fall from conveyor belt returns, causing extensive housekeeping problems unless deliberately removed. As a mass, the material has an angle of repose of nearly 90°, is unattractive to vermin and will start composting if enclosed in a storage device for more than a few days, becoming lumpy, hot (about 160°F) and difficult to manage.

The light materials fraction is a product from which most energy conversion products are eventually derived and if metals or glass are also removed, it may be a logical first step for a community, regardless of the type of back end system chosen. Its heating value is approximately 5,000 B.T.U. per pound as received, will usually include 25-35% moisture, and is essentially paper, film plastics, dust, fine yard clippings, and occasionally fabric. Its usual bulk density on a conveyor is 7-10 lbs/ft^3. Its particle size, depending on the process selected, may vary from lint up to 6" x 6" and even larger pieces in some instances. Within a given community, its characteristics may change slightly from day to day or season to season, but generally within the ranges described above, it is predictable. RDF can be used in almost any combustion unit, either alone or as a supplementary fuel and is usually delivered to the combustion unit either pneumatically or by a mechanical conveyor. It can be burned in suspension or on moving grates. If burning temperature exceeds 1700°, a material build-up inside the combustion unit may result, since garbage ash has a tendency to soften and melt above 1700°.

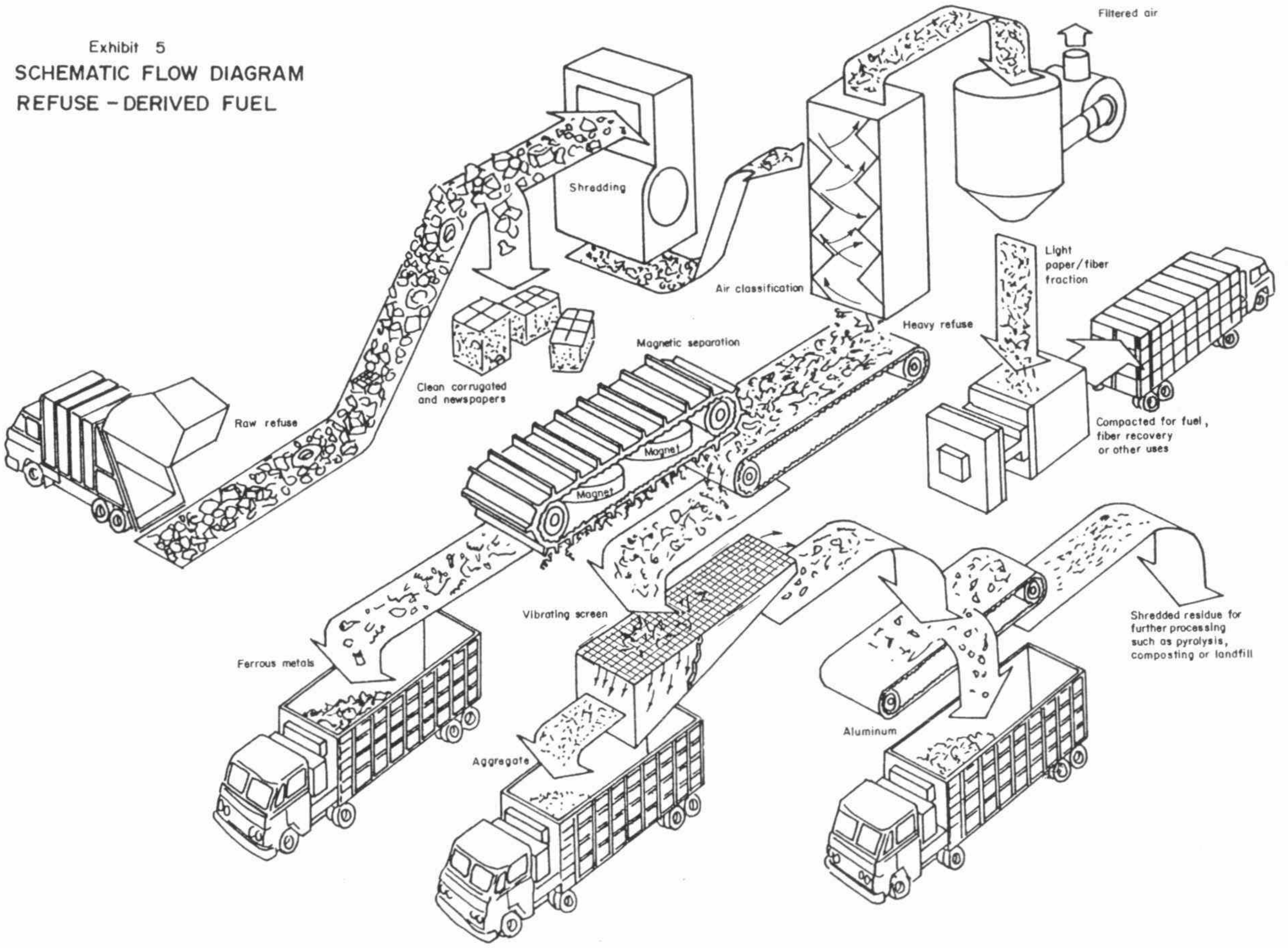
At approximately 10 million B.T.U.'s per ton, it can make a significant contribution to the energy requirements of a community, particularly where existing coal-fired furnaces can be found. Typical schematics of this RDF process flow are shown in Exhibit 5.

2.2.2 Package Steam Boilers, with the Possible Addition of a Turbine-Driven Electricity Generator

The small package steam boiler is frequently economically viable if a close physical and institutional relationship exists between the solid waste processing facility and the user of the steam. The steam must be utilized immediately by the user since there is no practical method available to store it. An economical arrangement can frequently be effected when such a unit can be tied into an existing industrial facility either as a standby unit or as a prime unit utilizing the existing steam distribution system within the facility. The principal drawbacks of small packaged steam boilers are that because of their small size, unit costs per ton may be higher than would be anticipated for say a 1000 ton per day system. Most of them are

Exhibit 5

SCHEMATIC FLOW DIAGRAM
REFUSE - DERIVED FUEL


Filtered air
Shredding
Light paper/fiber fraction
Air classification
Heavy refuse
Magnetic separation
Clean corrugated and newspapers
Raw refuse
Magnet
Magnet
Compacted for fuel, fiber recovery or other uses
Vibrating screen
Shredded residue for further processing such as pyrolysis, composting or landfill
Ferrous metals
Aluminum
Aggregate

equipped with afterburners in which the initial combustion process is accomplished in an oxygen starved atmosphere under semi-pyrolytic conditions and the resultant combustion gases from this process are burned in an afterburner using excess air. If the dwell time within the unit is adequate, fairly clean combustion can result, but in some areas with extremely high air quality standards, it may be necessary to add an air clean-up unit downstream from the combustion system. Most of these units use auxiliary fuel only for initial start-up, although some also require auxiliary fuel in the afterburner.

A number of processes were reviewed for the Lindsay area including CICO Resource Recovery Systems, Consumat Systems, Kelly-Hoskinson, Sunbeam Equipment Corporation, and other less well-known systems. Certainly several of these systems, either as single or multiple units, could be adapted to accommodate Lindsay's requirements. Illustrations of Consumat and Sunbeam equipment are given in Exhibits 6 and 7.

As an alternative to selling the steam to an external user, it may be used to power a turbine which in turn drives an electrical generator. Packaged turbine-generator sets in appropriate sizes are readily available, and there is no technological problem in adding this equipment to a steam-producing incinerator. The economics of such a course are discussed later.

2.2.3 Pyrolysis

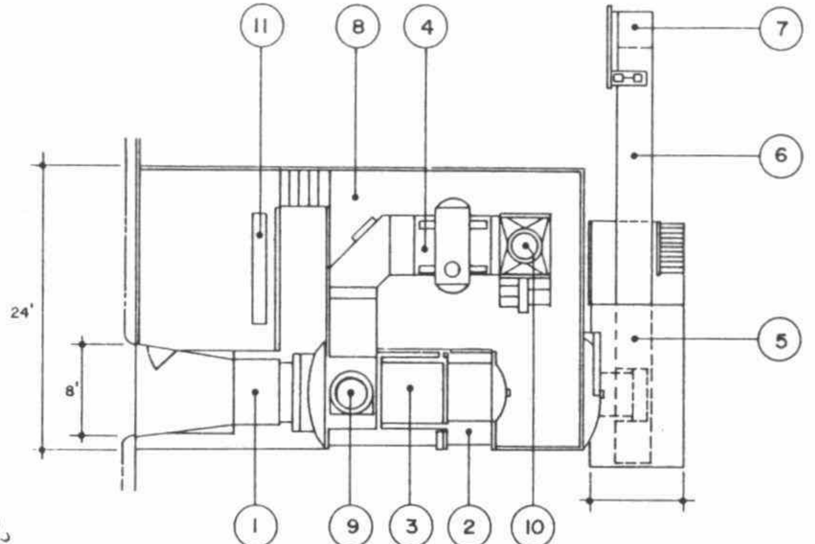
Pyrolysis is a process whereby organic materials are heated in the absence of oxygen to produce a gaseous or liquid product and a solid carbon-rich residue. There is no question that pyrolysis is technically proven. Man has been pyrolyzing coal for hundreds of years to produce coke. Wood has been pyrolized for thousands of years to produce charcoal as a batch process. In recent years, there have been many processes under development which utilize municipal solid wastes as their basic source of material. Large expenditures have been required to develop innovative material handling techniques for accomplishing this process. Although pilot plant operations have been built in sizes up to 200 tons per day, and Monsanto has built a 1000 tons per day facility which is still in shakedown, refuse pyrolysis

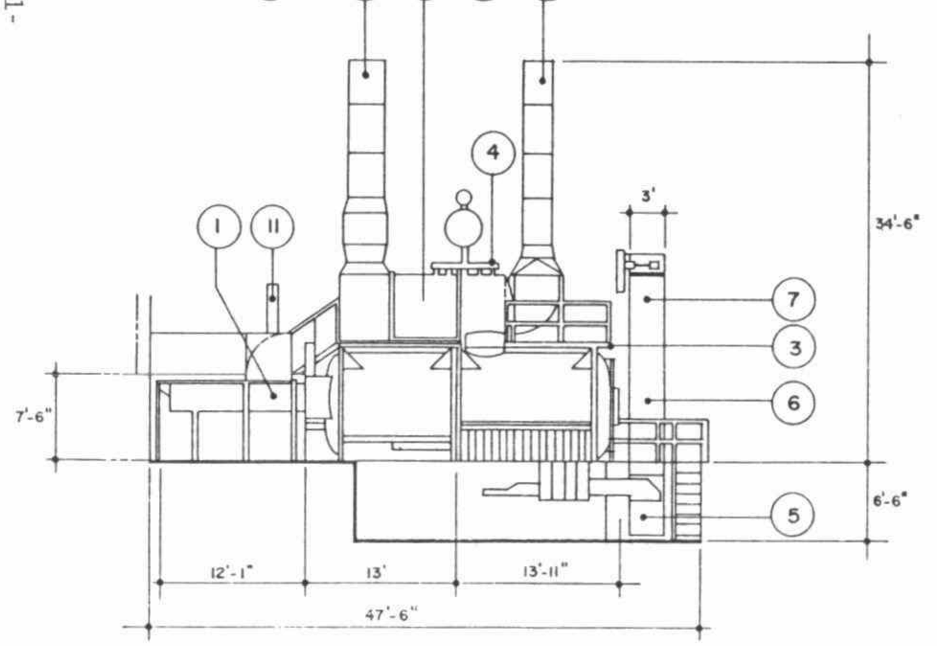
Exhibit 6

SCHEMATIC SKETCH

CONSUMAT INCINERATION WITH ENERGY RECOVERY (25 T/DAY SIZE)

1 LOADER
2 DISTILLATION CHAMBER
3 OXIDATION CHAMBER
4 ENERGY SYSTEM
5 WET ASH SUMP
6 ASH CONVEYOR
7 ASH DISCHARGE
8 STRUCTURAL PLATFORM
9 DUMP STACK
10 ENERGY STACK
11 CONTROL PANEL





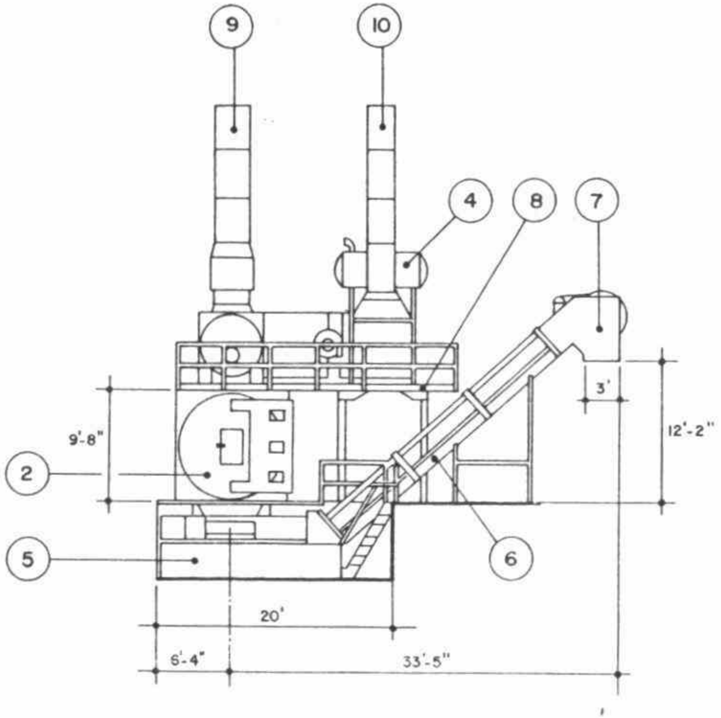
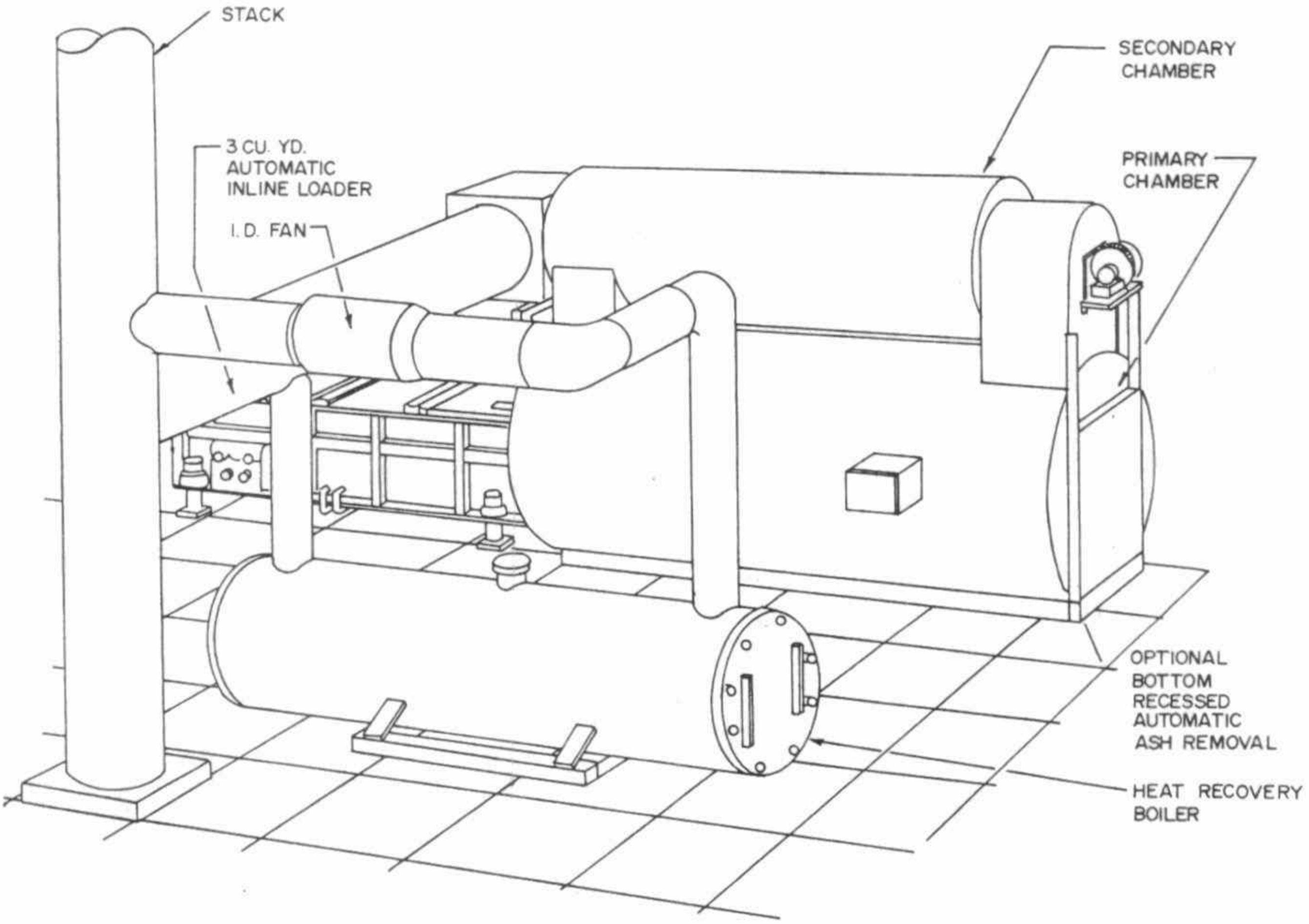


Exhibit 7

SCHEMATIC SKETCH - SUNBEAM INCINERATOR


STACK
SECONDARY CHAMBER
3 CU. YD. AUTOMATIC INLINE LOADER
PRIMARY CHAMBER
I. D. FAN
OPTIONAL BOTTOM RECESSED AUTOMATIC ASH REMOVAL
HEAT RECOVERY BOILER

as a process is still an emerging technology. Several small processes now under development, such as the Deco process or the Pyrolysis Systems, Inc. process,could be operational within the next year.

In a basic pyrolysis system, solid waste feedstock, preferably with metals and glass removed first, is fed continuously into a pyrolytic reactor and heat is applied externally to drive the reaction. As the waste is "cooked", the pyrolytic low grade gases or liquid evolved are drawn off the reactor, quenched and stored or burned in a nearby combustion chamber. There have been many proposals to utilize these pyrolysis products as fuel for power plants, as well as burning the products on site to produce steam for use by a public utility or industrial user. Some other variations include the burning of pyrolysis products in the gas turbine or internal combustion engine adjacent to the pyrolysis facility to produce electrical power for resale. Other interesting proposals include the transformation of the pyrolysis gases into useful chemical products such as methanol, benzene or ammonia. The more processes that are incorporated between receipt of garbage and final generation of usable energy, the higher the costs of the system must be and the lower the overall delivery efficiency of the system. Therefore, particularly in a small facility, the shorter the energy conversion cycle the more economical the process is likely to be.

A typical process flow diagram of the pyrolysis process is given in Exhibit 8 and an illustration of the Purox system in Exhibit 9. Although pyrolysis may be a preferred process in the future, it is not considered the best alternative in this application because of Lindsay's special and immediate requirements.

2.2.4 Scaled-Down Incinerators, Waterwall Combustion Units, and Industrial Boilers

Any number of manufacturing concerns produce incinerators, waterwall combustion units and industrial boilers. Most of these systems involve utilization of a basic incineration unit with waste heat recovery, and are usually capable of accepting either RDF or unprocessed wastes. Because the heat reaction is direct combustion and not pyrolytic, in most cases rather elaborate

Exhibit 8

SCHEMATIC SKETCH – PYROLYSIS PROCESS

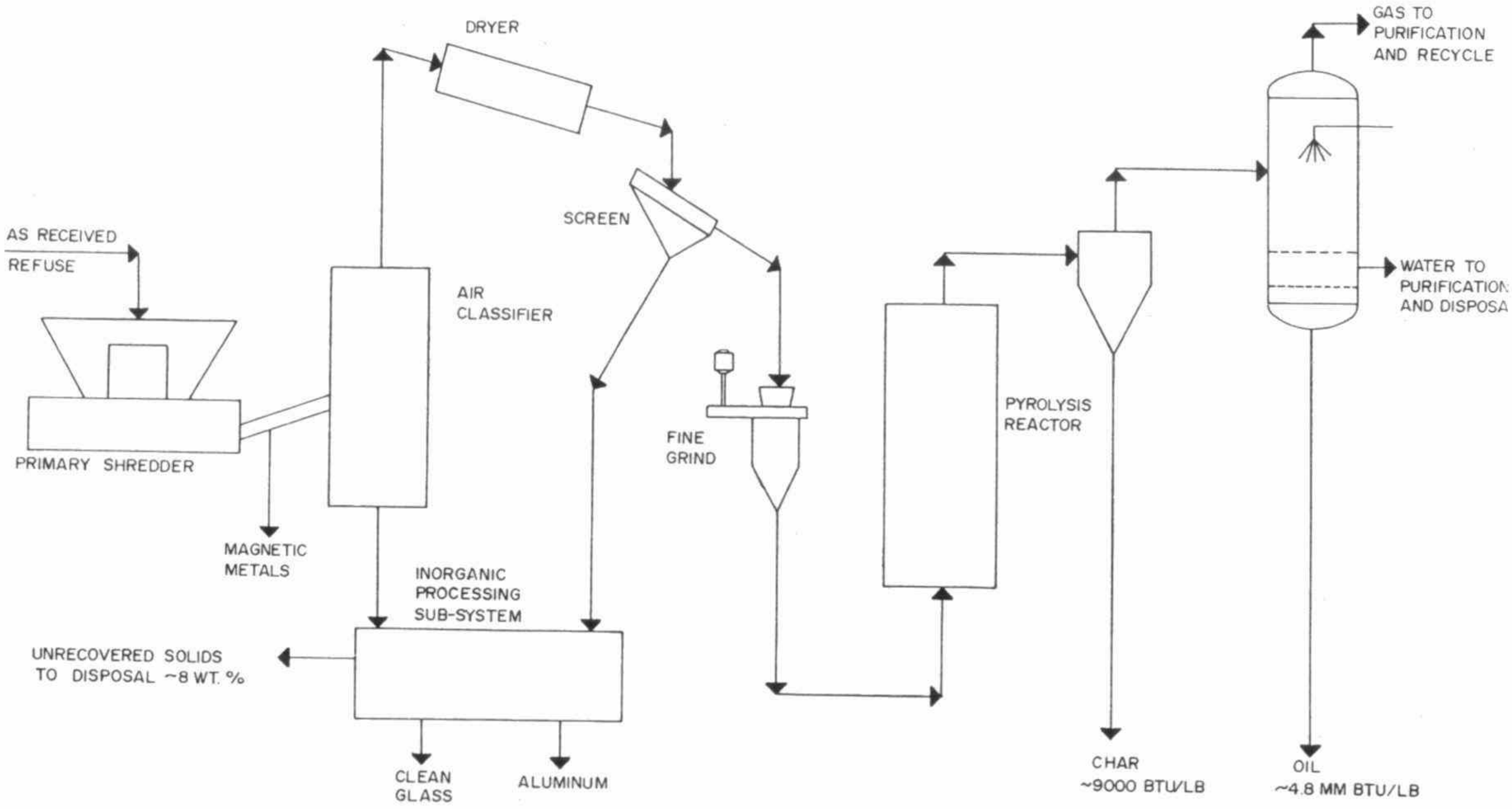


Exhibit 9

SCHEMATIC SKETCH - PUROX PROCESS

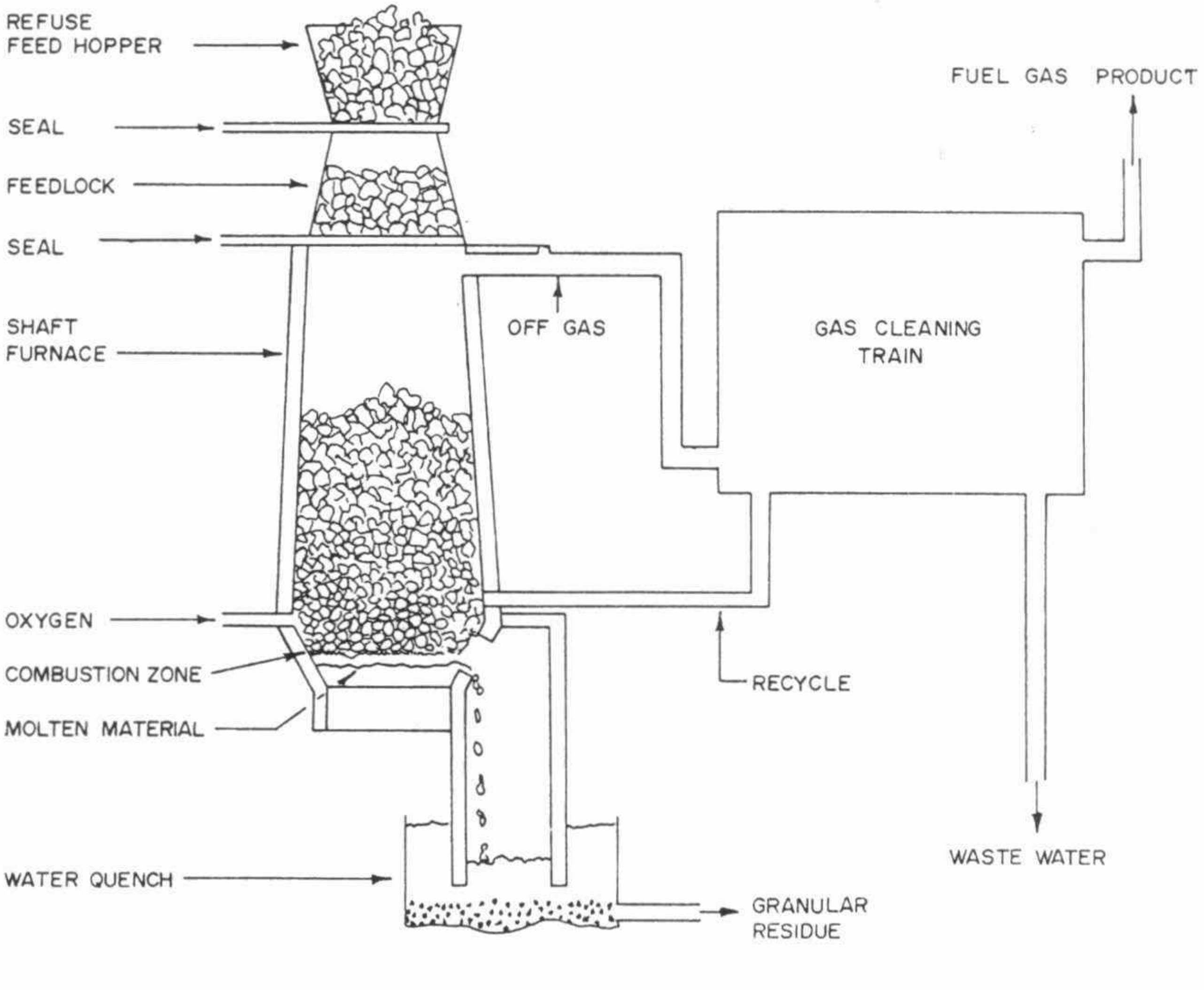
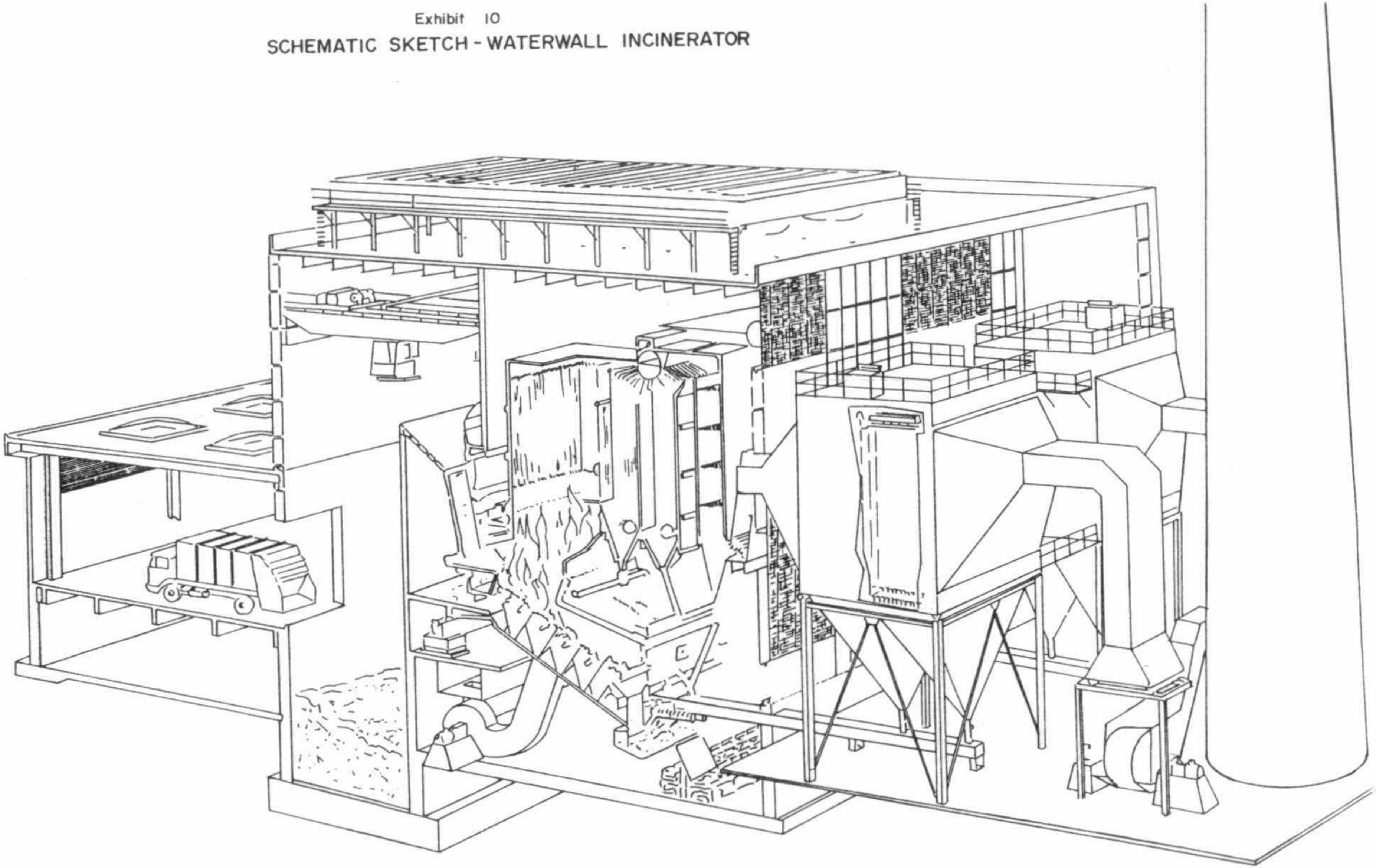


Exhibit 10

SCHEMATIC SKETCH - WATERWALL INCINERATOR



air clean-up equipment is required to meet existing air quality standards. A second even more critical drawback is one of size. Very few companies manufacture this type of hardware on a scale that would be economically viable for the Town of Lindsay since they are usually designed for very large industry or for large city applications where wastes are being processed in hundreds or even thousands of tons per day. In short, small community applications are not a suitable marketplace for waterwall combustion units and industrial boilers. They are proven, however, and in those areas where economics warrant it, they probably are quite a reasonable solution to the solid waste disposal problem. An illustration of a major incineration installation is given in Exhibit 10.

2.3 MARKET SURVEY

The major users (both private and public) of energy in Lindsay were surveyed to establish the likely market for steam or RDF on a year-round basis. Some users require steam 7 days a week, 24 hours a day; others only 5 days a week for 16 or 24 hours/day; steam pressures required are generally around 125 p.s.i. dry saturated.

The examination of the major industrial energy users in the Town of Lindsay revealed that those using significant quantities of heat energy to make process steam (and thus having year-round demands) are four industries - Union Carbide, Abex Industries, Armstrong Cork and Reichhold Chemicals - located in the N.E., and one industry - Uniroyal - located in the S.W.

Four possible potential customers were assessed among public energy users - Town Hall Complex, Sir Sandford Fleming College, Ross Memorial Hospital and Lindsay Aquatorium. The only major year-round user of heat energy (again to make steam) was found to be the hospital.

None of the facilities surveyed uses coal or wood-fired heating equipment which could allow the use of RDF in existing equipment. Consideration was given to finding potential RDF users in the immediate area or within economic trucking distance. The only potential user identified was St.

Mary's Cement at Bowmanville. However, the demonstration project at the Canada Cement plant in Woodstock has not yet proved the acceptability of RDF there and it is most unlikely that the quantity of fuel possible available from Lindsay would be adequate to persuade St. Mary's to consider the possible conversions necessary to accept it.

Preparation of RDF is therefore not further considered as a competitive method of obtaining energy from Lindsay's refuse.

2.4 SUMMARY OF AVAILABLE TECHNOLOGY AND MARKET DEMANDS

In conclusion, after careful review of the energy conversion systems that can be most readily adapted to the Town of Lindsay's requirements, it it suggested that small packaged steam generator systems similar to Consumat, Sunbeam, or their equivalent would be the most viable solution for detailed analysis.

CHAPTER 3 - THE CONCEPTUAL SYSTEM AND LOCATION

3.1 CONCEPTS

The conceptual system flow chart is shown in Exhibit 11.

It consists of a combined incinerator and steam boiler to which general residential, commercial and industrial waste is trucked. Delivery would be directly into the plant building, after passing over scales to record the weight of all refuse delivered. 'White goods' would be sorted out and stacked for scrap sales. A guillotine would be used for cutting oversize lumber, etc. to processable size. A small loader would be used to sort and load the incinerator loading hopper.

The package incinerator unit would have automatic loading and ash removal.

Supplementary fuel would be used to initiate combustion in the primary chamber and to fuel the afterburners which would be used to achieve the high temperatures required to bring emissions to within the Ministry of Environment standards.

Steam would be generated in the heat recovery units, with flow recorded and kept as even as possible and piped to a nearby user. The condensate would be piped back to the plant to be turned into steam again.

The user could be either an external user, or the plant's own turbine-generator, or (by designing the system to produce superheated steam) both. These three possible user configurations are shown in Exhibit 12. The output of the electrical generator could be offered for sale to the Lindsay Hydro Electric System who have expressed interest in principle.

Ash would be automatically discharged to ash pits, where water spray would be used to keep down dust. Ash would then be removed by conveyor for trucking to a landfill site, using covered containers for transfer.

Exhibit II

SCHEMATIC DIAGRAM - CONCEPTUAL SYSTEM FLOW CHART

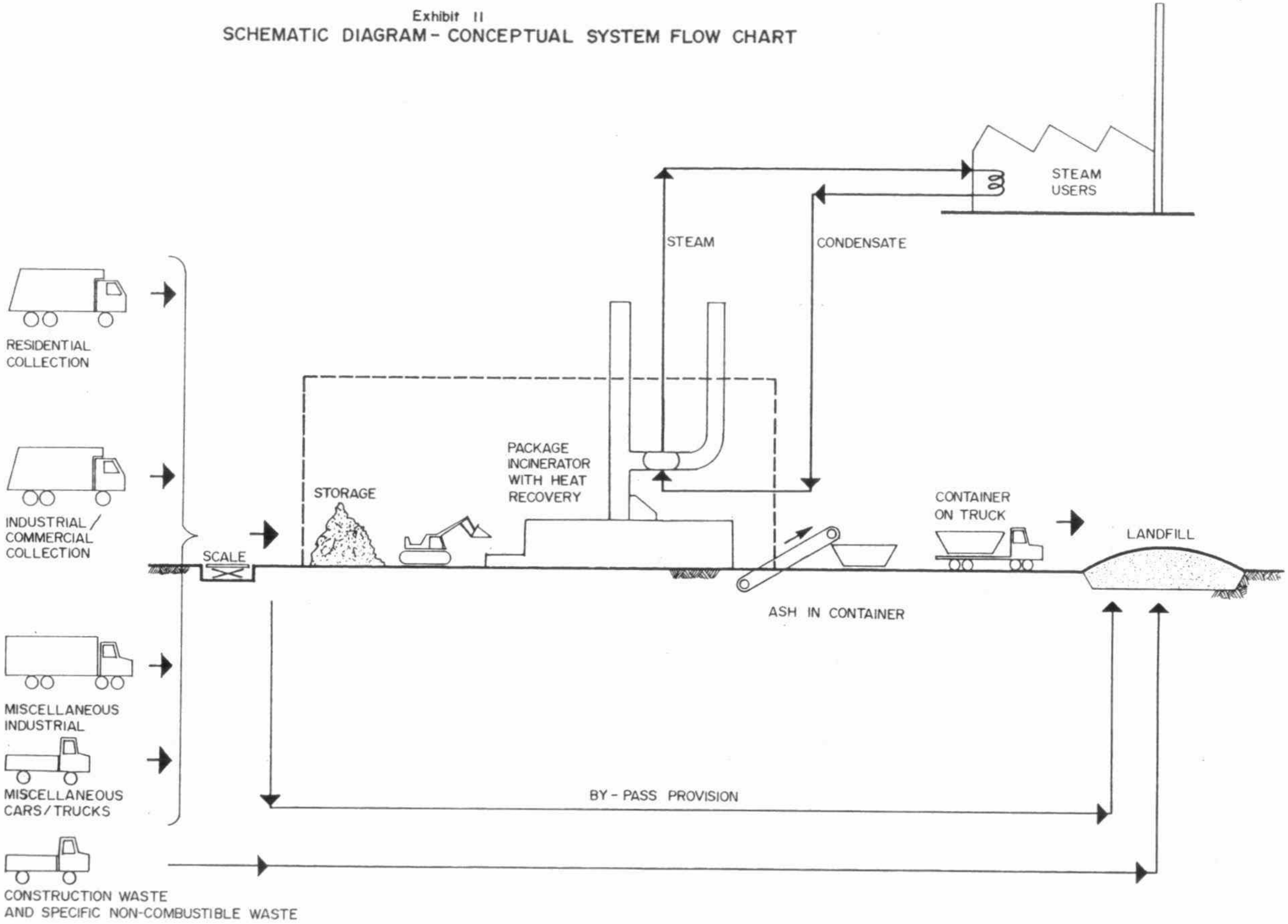
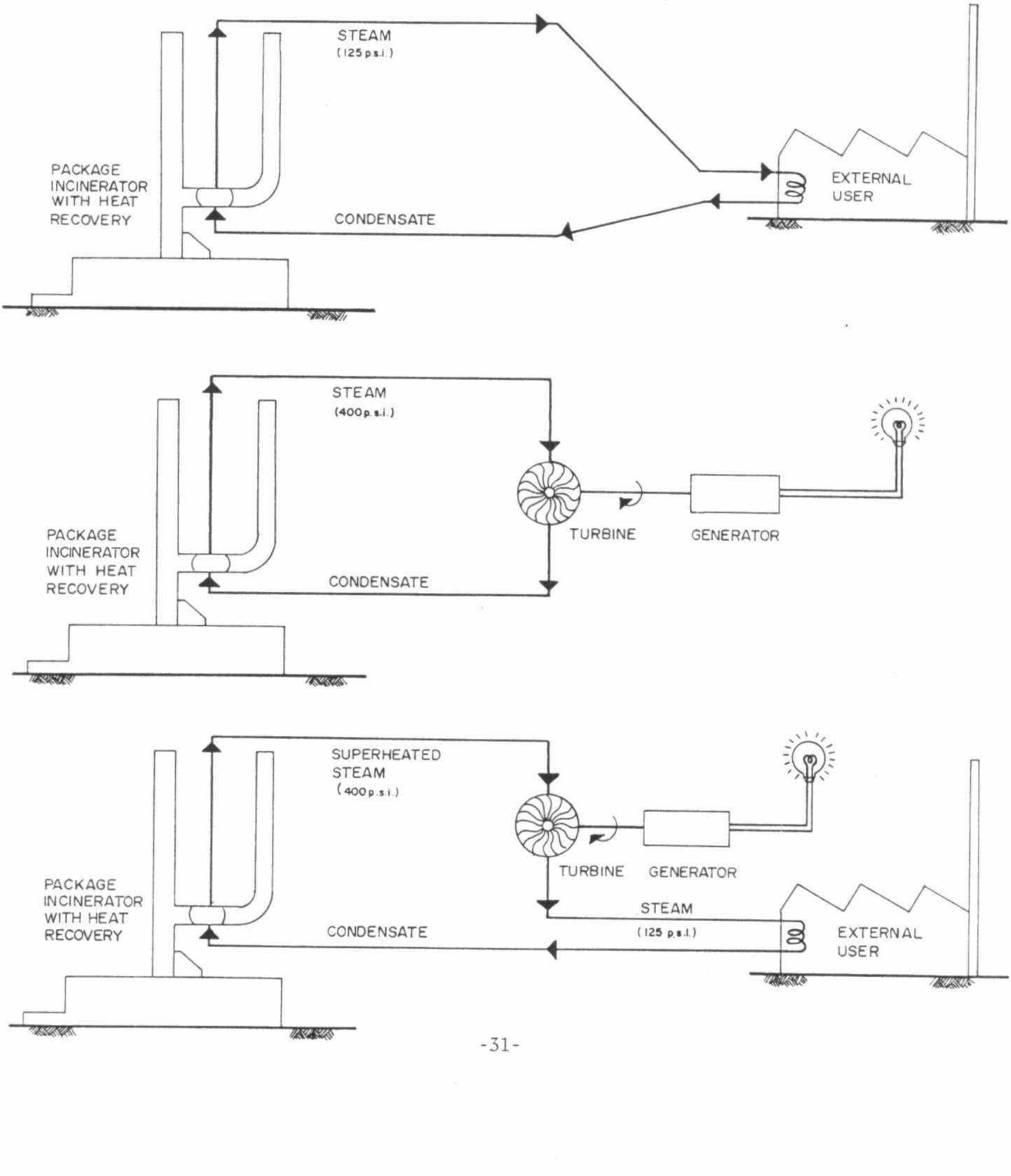

STEAM USERS
STEAM
CONDENSATE
RESIDENTIAL COLLECTION
INDUSTRIAL / COMMERCIAL COLLECTION
MISCELLANEOUS INDUSTRIAL
MISCELLANEOUS CARS/TRUCKS
CONSTRUCTION WASTE AND SPECIFIC NON-COMBUSTIBLE WASTE
SCALE
STORAGE
PACKAGE INCINERATOR WITH HEAT RECOVERY
CONTAINER ON TRUCK
LANDFILL
ASH IN CONTAINER
BY - PASS PROVISION

Exhibit 12

SCHEMATIC DIAGRAM - STEAM / TURBINE-POWER GENERATION



Based on 1977 estimated figures, total flow through an energy recovery plant would average 322.1 tons per week or 16,700 tons per year. Based on normal weight reductions through incineration for the types of waste involved, this would yield approximately 17% ash or 2,800 tons to be taken to landfill. An estimated 800 tons of construction wastes would go directly to landfill.

Provision should be made for some additional by-passing of wastes to landfill, which could be required at unexpected peak flows, on occasions of plant downtime or on identification of specific loads of non-combustible materials other than construction wastes. It is possible that in the order of 10% at the nominal plant throughput could have to be by-passed in this way. Total landfill capability required is thus estimated at 5,000 tons per year.

Note that even though a landfill site is still required under this concept, its life will be considerably longer than if all wastes were directed to it.

3.2 CRITERIA

The criteria used in evaluating the applicability of a central facility for one or more users were:

1. The pattern of supply of steam from the incinerator, and the extent to which it matches the demand for steam by the user.
2. Availability of a site which is publicly acceptable and is within economic distance of the potential user(s).
3. The practicability of the user(s) accepting steam into the facility(s) system.
4. The user(s) attitude to such arrangements and the probability of the user continuing to be a user over the economic life of the energy recovery plant.
5. Relationship of plant to the landfill site.
6. Feasibility of connecting output of an electrical generator to local PUC power network.

3.3 SUPPLY OF STEAM

Inspection of the wastes suggests that they fall predominantly into three classifications as follows:

Residential	Approx. 50% Moisture	Approx. 4,300 B.T.U./Lb.
Industrial/Commercial	Approx. 25% Moisture	Approx. 6,500 B.T.U./Lb.
Specific Industrial	Approx. 10% Moisture	Approx. 8,500 B.T.U./Lb.

Total available heat energy from Lindsay's waste steam is thus calculated in B.T.U.'s as given in Exhibit 13, together with estimated possible steam generation.

3.4 EFFECT OF DISTANCE BETWEEN PLANT AND STEAM USER

Economic distance for separation of a steam user from the heat generating facility depends on the quantities involved and the condition for the routing of lines. Generally, heat losses from steam lines in excess of 1/2 mile in length within the Town would have an unacceptable impact on the economic viability of a central steam raising facility. Heat losses in well insulated lines up to 1/2 mile long would, however, have no significant impact on energy balance calculations.

Currently, installation of the required insulated steam lines would cost of the order of \$50 - \$100 per foot where direct burial is possible, and of the order of \$150 - \$200 per foot in built-up areas where concrete enclosures and frequent road crossings are required.

3.5 RANKING OF OPPORTUNITIES

Comparing the supply of steam with the demand, taking each potential user on its own, and leaving aside for the moment the option of electricity generation, it is clear that the two leading market opportunities are Union Carbide and the Ross Memorial Hospital.

Union Carbide runs its boilers not only to raise steam but also to provide a means of burning off hydrogen sulphide-contaminated air (which is a

Exhibit 13

ESTIMATED HEAT AVAILABLE FROM SOLID WASTES (1977)

	Estimated Tons/Week						Heat Value B.T.U./Lb.	Estimated M.M.B.T.U./Week					
	"Optimistic"			"Pessimistic"				"Optimistic"			"Pessimistic"		
ORIGIN	Min.	Max.	Avg.	Min.	Max.	Avg.		Min.	Max.	Avg.	Min.	Max.	Avg.
Residential	65.3	116.2	90.8	As Optimistic			4,300	561.6	999.3	780.9	As Optimistic		
Misc. Ind./ Comm.	87.3	155.2	121.3	As Optimistic			6,500	1134.9	2017.6	1576.9	As Optimistic		
Specific Industries	79.2	140.8	110.0	1/2 Optimistic			8,500	1346.4	2393.6	1870.0	1/2 Optimistic		
TOTALS	231.8	412.2	312.1	192.6	341.8	267.1		3042.9	5410.5	4227.9	2369.7	4213.7	3292.8
Lbs./Hour of Steam - 5 x 24 Hr./Day Basis (125 psi dry saturated)								12,700	22,500	17,600	9,900	17,600	13,700
- 7 x 24 Hr./Day Basis								9,100	16,100	12,600	7,100	12,600	9,800

Note: Heat conversion assumption is 1,200 B.T.U./Lbs. at 125 psi, dry saturated, and 60% boiler efficiency.

waste by-product of their process). It is possible to duct this air to the garbage incinerator and to burn it there, thus adding to the demand for steam (demand which would otherwise have been filled by the need for Union Carbide to run a boiler just to burn the hydrogen sulphide). It would be an added responsibility for the Town to burn the hydrogen sulphide in the garbage incinerator; however, this could well mean a more efficient way of disposing of the contaminant (because parallel facilities would be available) than now exists, leading to an overall improvement of the environment. No doubt the terms of the agreement would reflect the added responsibility. Certainly, the burning of the contaminant by the Town indicates a substantially higher market for steam, as shown in the following table.

STEAM SALES AT 1977 LEVELS
(Millions of Lbs. Steam per Year)
(Based on 7 x 24 Hr. Day Operation)

	OPTIMISTIC GARBAGE SCENARIO	PESSIMISTIC GARBAGE SCENARIO
To Union Carbide, if Town does H_2S burn-off	111	86
To Union Carbide, if they do their own H_2S burn-off	82	69
To Ross Memorial Hospital	83	77

Initial reaction from Town officials is that they would favour the approach of the Town burning off the hydrogen sulphide.

The supply and demand for each of these cases is shown graphically in Exhibit 14.

3.6 DESIRABILITY OF HAVING ONLY ONE STEAM USER

It is theoretically possible to supply steam to more than one end user, and so increase the demand to the point where all the supply can be used. For example, steam might be offered to both Union Carbide and Reichhold Che-

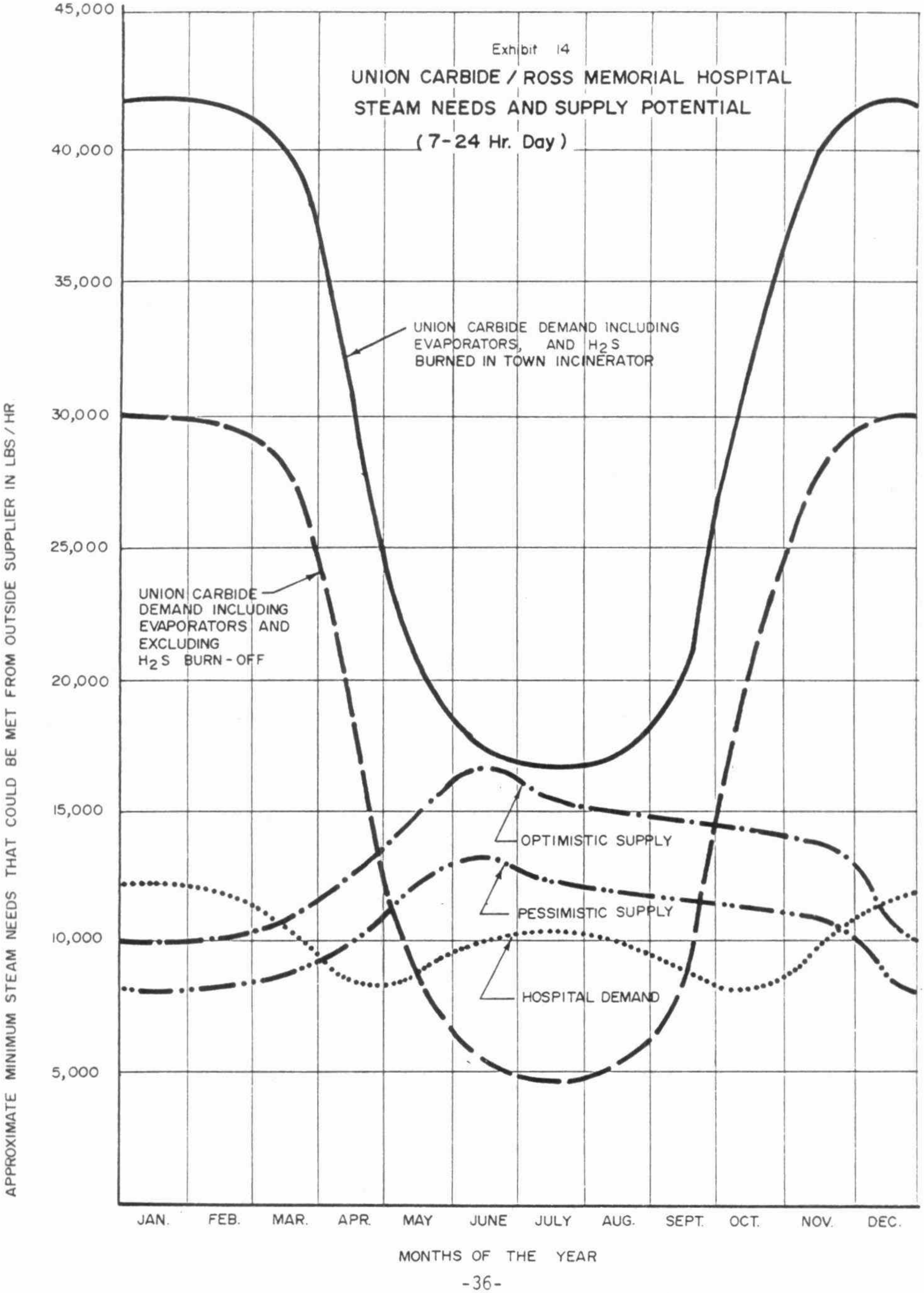


Exhibit 14

UNION CARBIDE / ROSS MEMORIAL HOSPITAL
STEAM NEEDS AND SUPPLY POTENTIAL
(7-24 Hr. Day)

micals, or to both Union Carbide and Armstrong Carpets. However, there are some important business and engineering reasons why every effort should be made to promote a viable scheme with only one company:

- the form of agreement will be simplified and will be much easier to operate (for example, in regard to procedures when the plant cannot supply steam).
- it is highly desirable for the incinerator plant to use boiler feedwater from the user. This avoids duplication of water treatment plants; the user would have to provide the feedwater for his own boilers anyway, and responsibility for the quality of the feedwater therefore lies with the user. There are obvious complications if feedwater from two users is mixed, or if a user does not operate a closed-circuit system.
- there is more likelihood of being able to minimize the requirements for stationary engineers.

It is therefore proposed to continue only with the analysis of the two alternative markets described above, namely, either Union Carbide alone, or the Ross Memorial Hospital alone. Later in the analysis, the option of electricity generation will be superimposed.

Sites are available nearby in both cases, and are shown diagramatically in Exhibits 15 and 16 and at a larger scale in Exhibits 17 and 18.

It appears possible that a waste incineration plant could be located on vacant land to the north of Highway 7A and approximately 1/3 mile to the west of the hospital. This land is zoned Institutional and owned by the Province of Ontario. For the Union Carbide alternative, the Town owns land between the Union Carbide site and the Freightmaster property on Mount Hope Street. In both cases, accesses would have to be negotiated.

In the case of the Hospital, the steam lines would be longer and would involve an underground road crossing.

It is possible that the site adjacent to Union Carbide would be more acceptable to the public, since it is part of an existing industrial complex.

Exhibit 15

INCINERATION PLANT TOWN LANDS UNION CARBIDE

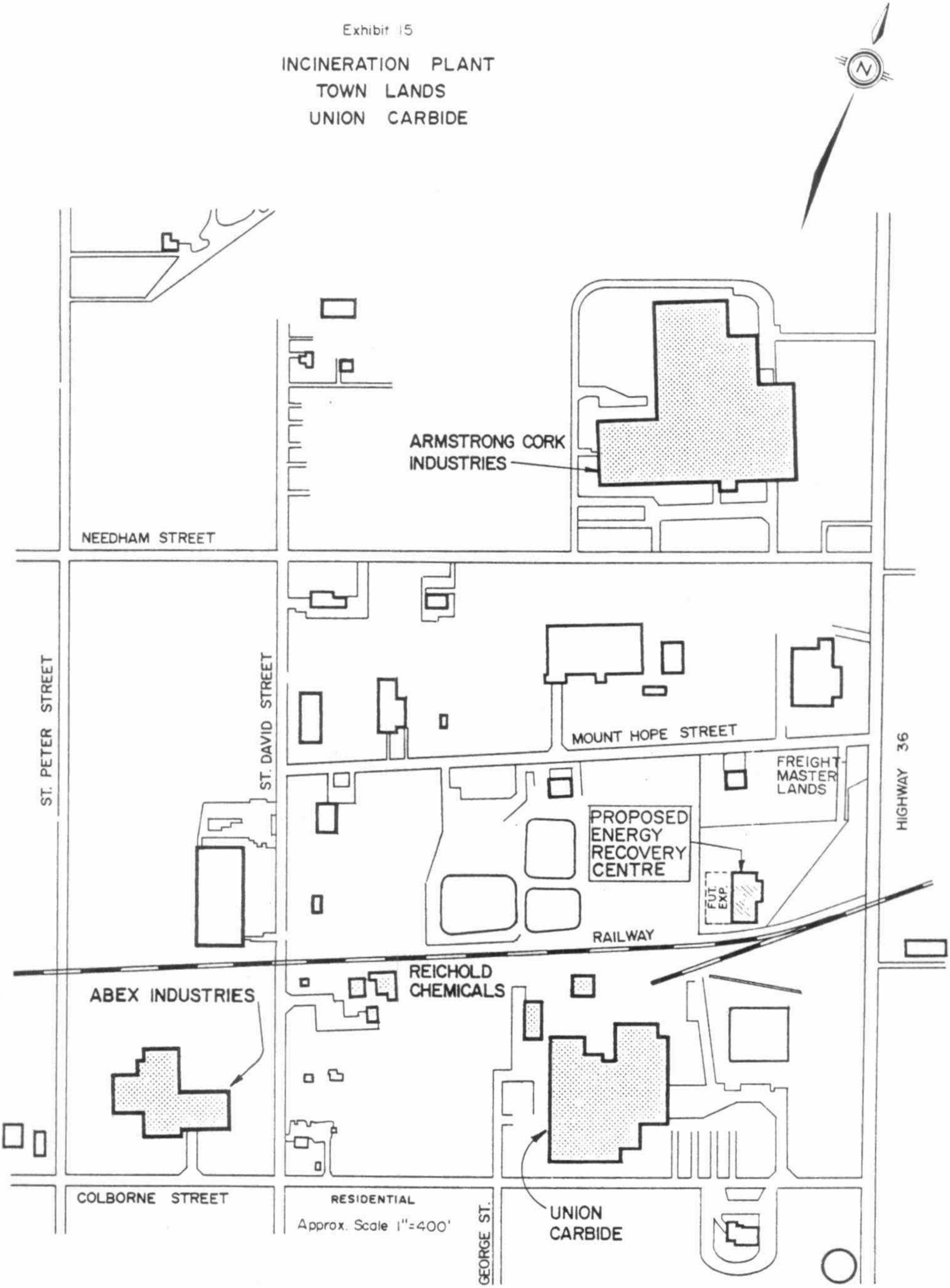
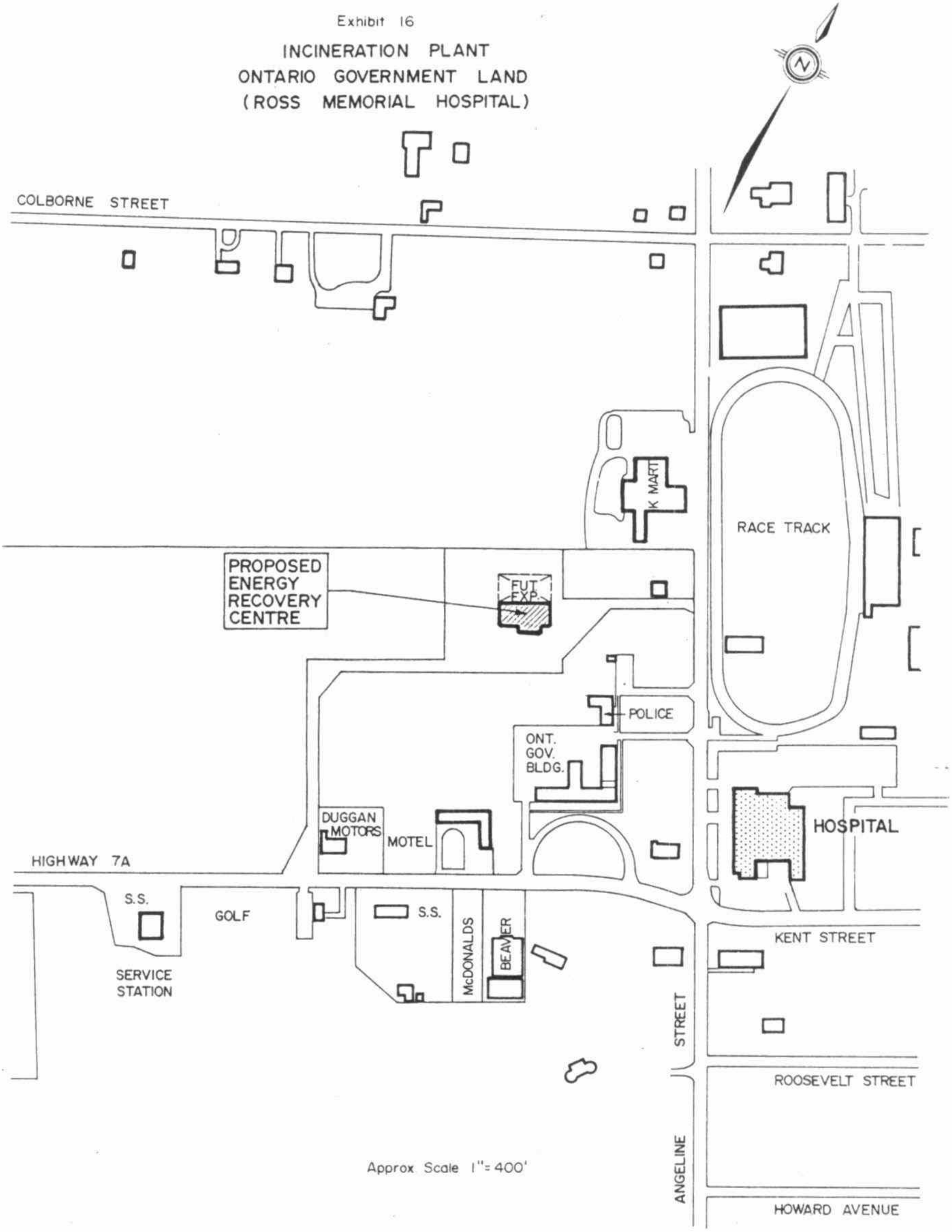


Exhibit 16

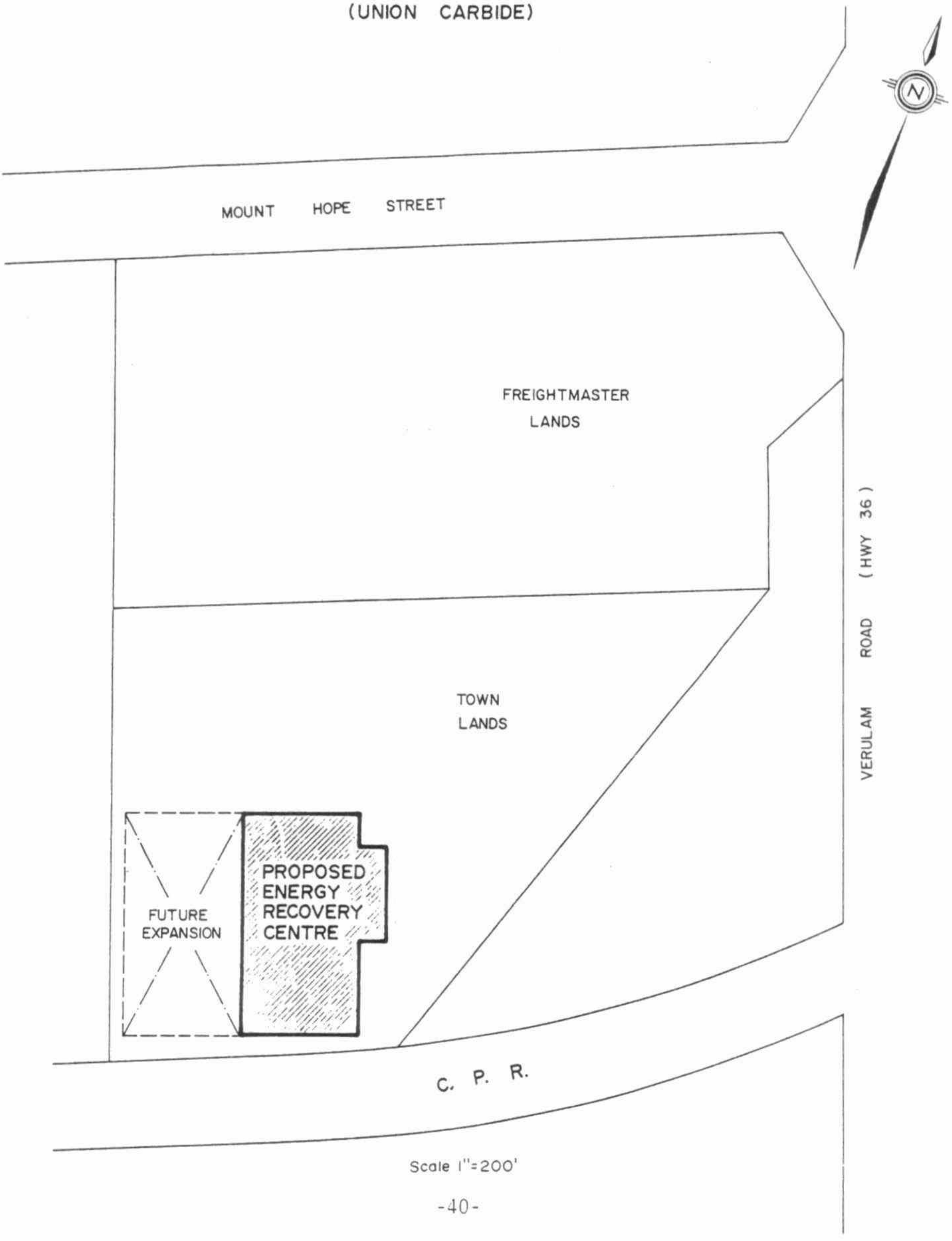
INCINERATION PLANT
ONTARIO GOVERNMENT LAND
(ROSS MEMORIAL HOSPITAL)



Approx Scale 1" = 400'

Exhibit 17

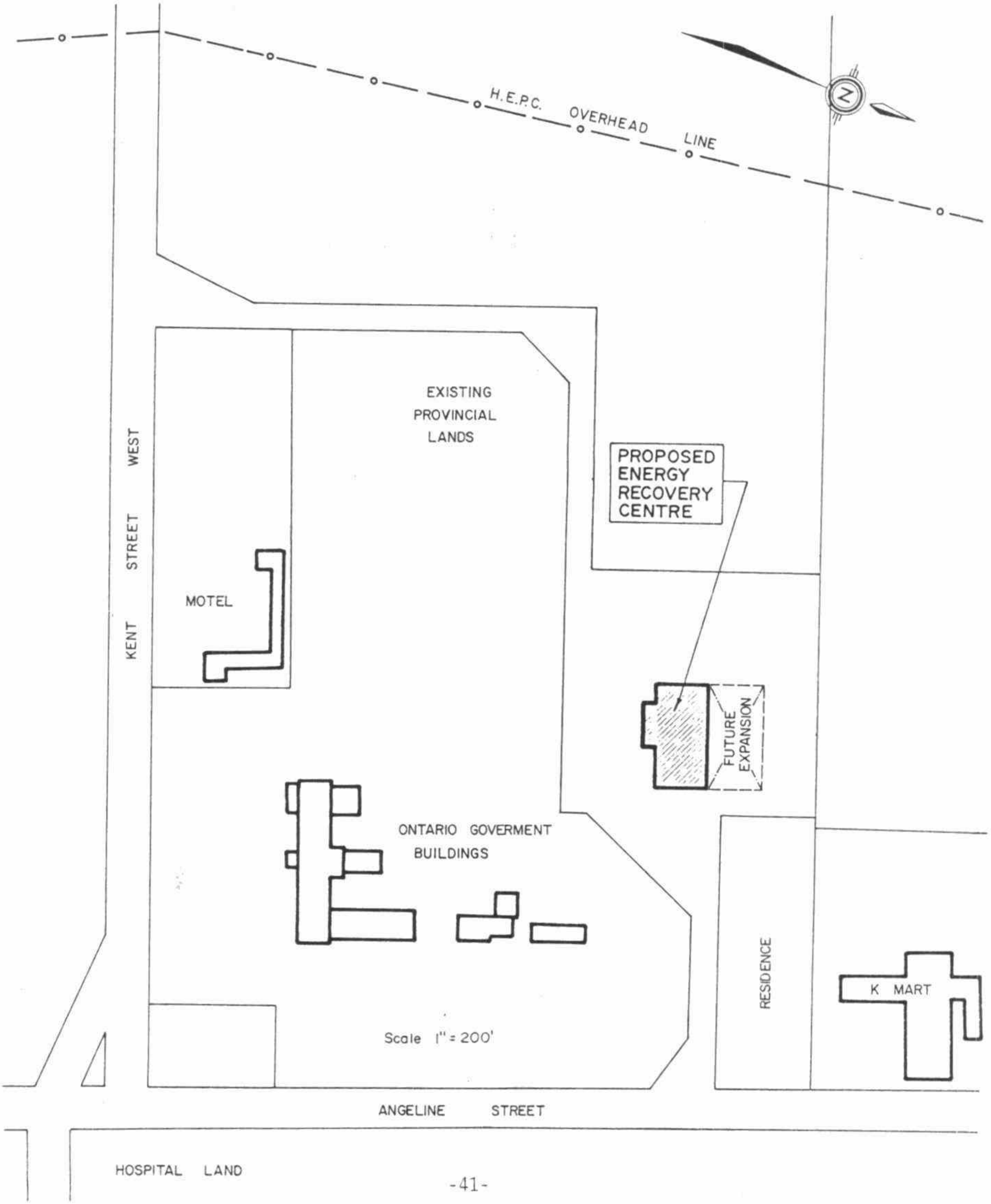
INCINERATION PLANT
SCHEMATIC LAYOUT & SITE UTILIZATION
TOWN LAND
(UNION CARBIDE)



Scale 1"=200'

Exhibit 18

SCHEMATIC LAYOUT & SITE UTILIZATION ONTARIO GOVERNMENT LAND (ROSS MEMORIAL HOSPITAL)



The site across from the hospital would be fairly close to a shopping centre and a hotel, as well as some public building, although there appears to be ample room for landscaping and screening.

The Union Carbide site is closer to the landfill site, thus facilitating ash disposal.

The financial security of the project will depend on whether the demand for steam will continue in the future. The Hospital as an institution is virtually certain to be there with its energy demands for many years. Union Carbide shows no signs of being anything other than an equally permanent member of the Lindsay community, but in deference to the risks that face all businesses, we would have to rank the Hospital as being more certain in its future.

Whichever alternative is chosen, if for some reason the steam demand were to disappear at some time in the future, it would still be possible to add a turbine-generator set and convert the incinerator plant to an electricity producer.

We have summarized the ranking of the two alternatives as follows:

	Hospital	Union Carbide
Steam Sales	Worse	Better
Security of future demand	Better	Worse
Probable demand increases	With Population	Not Known
Length (and hence cost) of Steam Lines	Worse	Better
Likely Public Acceptance of Site	Worse	Better
Distance to Land Fill	Further Away	Closer
Availability of Site	Equal	Equal
Zoning of Land for Plant	Institutional	?
Cost of Land	Owned by Ont. Gov't. Access and screening would have to be negotiated.	Owned by Town Access would have to be negotiated.

Based on the above comparison, the Ministry and the Town directed the consultants to continue analysis of the Union Carbide alternative only.

3.7 CO-GENERATION OF ELECTRICITY

Earlier, in Exhibit 12, the configurations of the electricity generator option were described. These options were evaluated against the datum of the Union Carbide market, by determining if there is a significant revenue advantage; further analysis would be warranted only if such an advantage is available.

The first step was the calculation of the value of steam produced by the garbage, measured in terms of the cost of the equivalent fuel (gas) that would have to be burnt in Union Carbide's boilers. Taking the price of gas at $2.00 per 1,000 cu. ft., a gas heat value of 1,000 B.T.U./cu. ft., a heat requirement of 1,000 B.T.U./lb.* of steam and a gas boiler efficiency of 80%, the energy replacement value of 1,000 lbs. steam is

$$\frac{1000 \text{ lbs. x } 1000 \text{ B.T.U./lb. x } \$2.00}{0.8 \text{ efficiency x } 1000 \text{ B.T.U./cu.ft. gas x } 1000 \text{ cu.ft. gas}} = \$2.50 \text{ **}$$

The value to Lindsay Hydro Electric System of power produced by the generator option has been taken to be a use charge of 9.3 mils per KWH plus a demand charge of $6.03 per KW of the 20-minute peak every month.

In the case of the option where there would be an end user of steam who requires service on, say, a 24-hour/day, 7 days/week basis, then an intermediate turbine-generator would have to run on the same basis. If, however,

---

* This calculation uses 1,000 B.T.U./lb. steam, whereas Exhibit 13 uses 1,200 B.T.U./lb. steam. The calculation above is concerned with how much Union Carbide would save by not making steam in their own boilers and is somewhat conservative. Exhibit 13 is concerned with making steam in the new plant; a higher figure is appropriate, and this also allows for heat losses in transporting both steam and condensate.

** Note also that the replacement value of $2.50 was used for the co-generation study and for the first-cut comparisons. It was later refined during detailed discussions with Union Carbide to $2.45.

Exhibit 19

ANNUAL REVENUE ANALYSIS OF TURBINE-GENERATOR OPTIONS

S = Steam Sales
D = Hydro Demand Revenue
U = Hydro Use Revenue

ALTERNATIVE	OPTIMISTIC SCENARIO	PESSIMISTIC SCENARIO
1. (Base Case) Generate steam at 125 psig and sell to Union Carbide		
(a) Town does H_2S burn-off	S =$277,000 D = 0 U = 0 $277,000	S =$215,000 D = 0 U = 0 $215,000
(b) Union Carbide does H_2S burn-off	S = 204,000 D = 0 U = 0 $204,000	S = 172,000 D = 0 U = 0 $172,000
2. Generate steam at 400 psig and pass through turbine-generator. Exhaust at 5 psia.		
(a) 24 hrs/day, 7 days/week	S = 0 U = 55,000 D = 49,000 $104,000	S = 0 U = 43,000 D = 38,000 $ 81,000
(b) 14 hrs/day, 5 days/week	S = 0 U = 55,000 D = 117,000 $172,000	S = 0 U = 43,000 D = 92,000 $135,000
3. Generate steam at 400 psig superheated. Drop to 125 psig across turbine, generating electricity. Sell steam at 125 psi to Union Carbide.		
(a) Town does H_2S burn-off	S = 255,000 U = 19,000 D = 17,000 $291,000	S = 199,000 U = 15,000 D = 13,000 $227,000
(b) Union Carbide does H_2S burn-off	S = 193,000 U = 19,000 D = 17,000 $229,000	S = 163,000 U = 15,000 D = 13,000 $191,000

there is no such constraint, a higher electrical peak could be achieved by running the plant on, say, a 14-hour/day, 5 days/week basis; this would increase the offset to the demand charge that Lindsay would otherwise have had to pay to Ontario Hydro. This "demand" revenue is vulnerable; it will only arise provided that the incinerator plant is producing electricity during the 20-minute period each month which would otherwise be the peak as far as Ontario Hydro are concerned, and it is not possible to predict when this peak period will occur.

The revenue analysis for the turbine-generator options is given in Exhibit 19.

Commenting on this analysis, it can be seen that there is no revenue advantage to having a turbine-generator without an end user of steam. The revenue is substantially increased by shortening the operating hours; this will also achieve some savings in operating staff, but not enough to outweigh

(a) the extra cost of sizing all equipment to meet a higher peak load,
(b) the fact that all of the extra revenue is vulnerable as described above.

With an end steam user, there is a possible extra annual revenue in the range of $12,000 - $25,000, and some of this is classified as vulnerable. It is not enough to represent a worthwhile return on the extra investment in the turbine-generator, additional building space, additional maintenance costs, and metering and connections to Lindsay Hydro Electric System.

CHAPTER 4 - DESIGN OF THE PLANT

The 1977 peak week of garbage has been shown in Exhibit 4 to amount to 412 tons (optimistic scenario). This is collected over 5 days, but the plan is to burn it over 7 days so as to provide continuous steam production. Storage space will be provided for garbage collected during the week and held to be burned at the weekend.

No one can predict whether the "optimistic" or "pessimistic" scenario will happen; indeed the actual situation may swing from one extreme to the other and back again at any time in the future as, for example, the value of waste paper for recycling changes. It is therefore prudent to size the plant for the "optimistic" peak, and to examine the financial feasibility of it under both "optimistic" and "pessimistic" operating conditions.

Thus the burning capacity required in 1977 is 59 tons/day, and storage will be required for about 177 tons for a long weekend.

With the growth assumption stated earlier, and assuming the plant could be in operation by the end of 1979, the peak burning capacity required would be 60 tons per day on opening, rising to 68 tons/day ten years after opening and 77 tons/day 20 years after opening. Storage requirements will rise to 204 tons and 231 tons respectively.

What time horizon should be used for sizing the design? There is no doubt that it is far cheaper to buy spare capacity in the form of a larger unit initially, than to add an additional unit in five or ten years time. An extra 15 tons/day capacity added initially can be obtained for under $100,000 whereas to add it later could cost about half a million dollars at today's prices. It is therefore recommended that units be considered in the range of 75 - 80 tons/day giving approximately a 20-year capacity for growth.

From the point of view of the garbage incinerator, it is desirable to operate it continuously and at full rated capacity, as this minimizes the use of auxiliary fuel and minimizes wear and tear. However, the supply of garbage varies substantially throughout the year. The plant size must be large enough to handle the peaks, but it must also handle the troughs without undue loss of efficiency.

The worst trough will be the "pessimistic" winter minimum, or 192.6 tons/week (see Exhibit 13). This is equivalent to a daily burning capacity of 28 tons/day on opening, 32 tons/day after ten years, and 36 tons/day after 20 years.

This range can best be accommodated by having a few smaller incinerators rather than one large one. However, there is a capital cost penalty, since the capital cost per ton of capacity rises as the units get smaller. For the purposes of this feasibility study, it is suggested that the best compromise would be to consider having two small units of unequal size, say with capacities of 25 tons/day and 50 tons/day. They will provide operating configurations of either 25 tons/day, 50 tons/day, or 75 tons/day, depending on whether either or both are fired up.

The amount of storage space needed has been indicated above to be up to 177 tons on opening, rising to 231 tons in 20 years, both of these being for a long weekend. Although there are several long weekends during the year, there is only one (Victoria Day) that coincides with the apparent peak in garbage generation; it is therefore questionable whether it is economically justifiable to design the storage building for this once-a-year event. For the time being, provision has been made for an arbitrary storage of 200 tons; it is recommended that holiday weekend operations be specifically discussed in negotiating the agreement with the steam purchaser and that the sizing of the storage space be reviewed then.

Taking a garbage density of 10 lbs/cu. ft. and a pile ten feet high, 200 tons will require 4,000 sq. ft. of floor space.

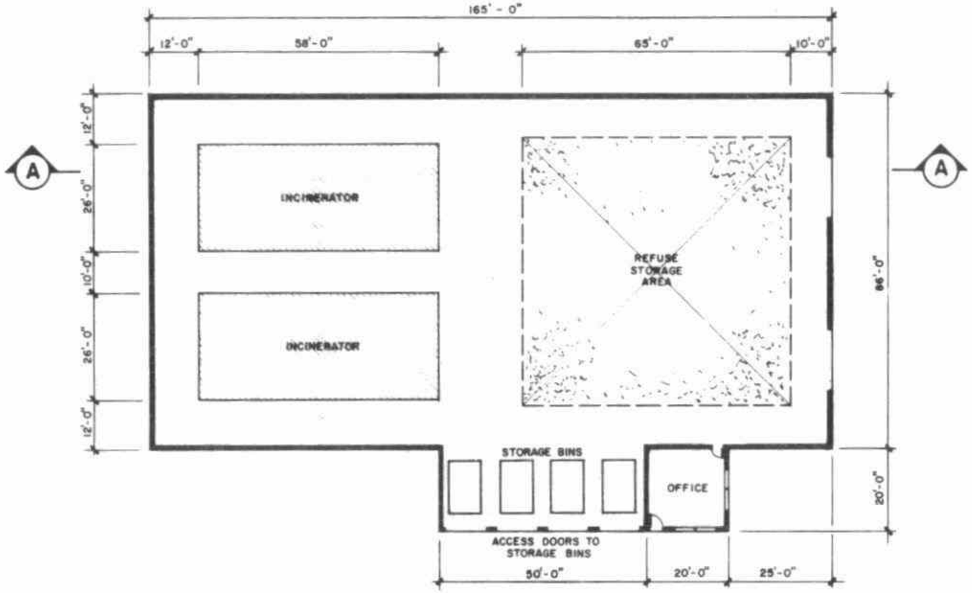
The annual garbage production in 1977 is estimated to be about 16,700 tons. Assuming an ash production of 17% by weight, this would have produced about 2,800 tons of ash if it has been incinerated. Taking an ash density of 45 lbs./cu. ft., the ash would occupy a volume of about 4,700 cu. yards.

Ash will be collected in bulk containers, say 30-yard capacity, as it is ejected from the incinerators. Thus there will be 156 loads of ash a year (or 3 a week) to be tipped at the landfill site.

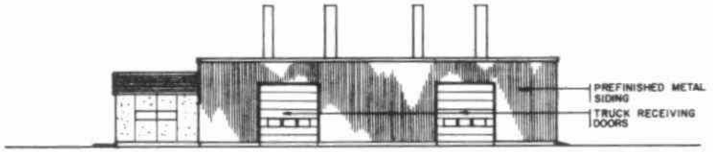
An outline plant layout is shown in Exhibit 20. This makes provision for the sizing as above, and also includes ancillary facilities of a small office and covered space for bins into which white goods and special loads of bottles or cans may be gathered. An artist's impression of the plant is shown in Exhibit 21.

A budget estimate has been prepared for the equipment, building, site works, and connections to the Union Carbide plant, but excluding any costs of land acquisitions. This estimate is $1,860,000 at March 1978 price levels and is detailed in Exhibit 22.

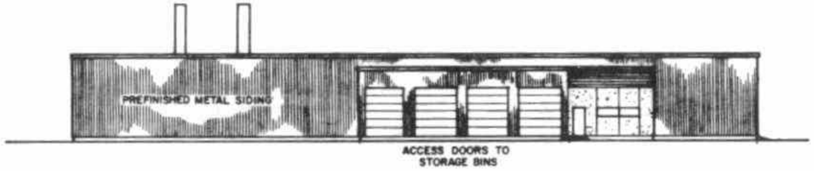
Exhibit 20



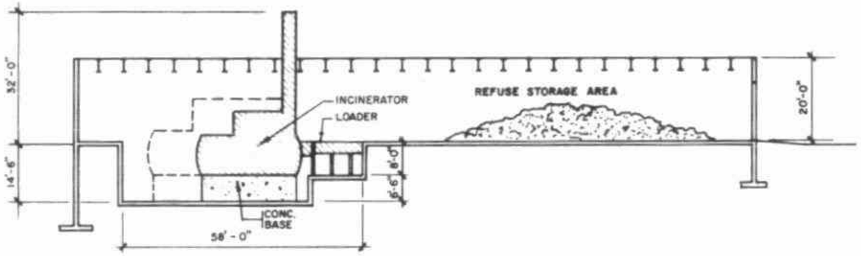
BUILDING FLOOR PLAN
SCALE: 1" = 30'-0"



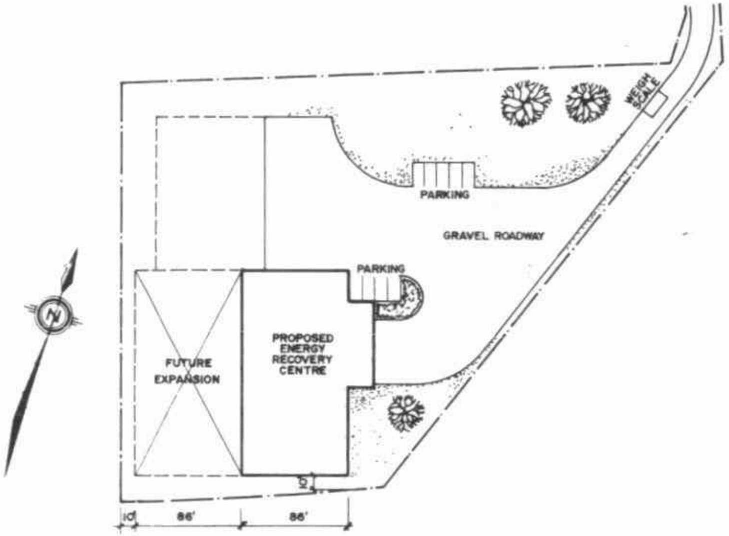
FRONT ELEVATION
SCALE: 1" = 30'-0"



LEFT ELEVATION
SCALE: 1" = 30'-0"



BUILDING SECTION A-A
SCALE 1" = 30'-0"

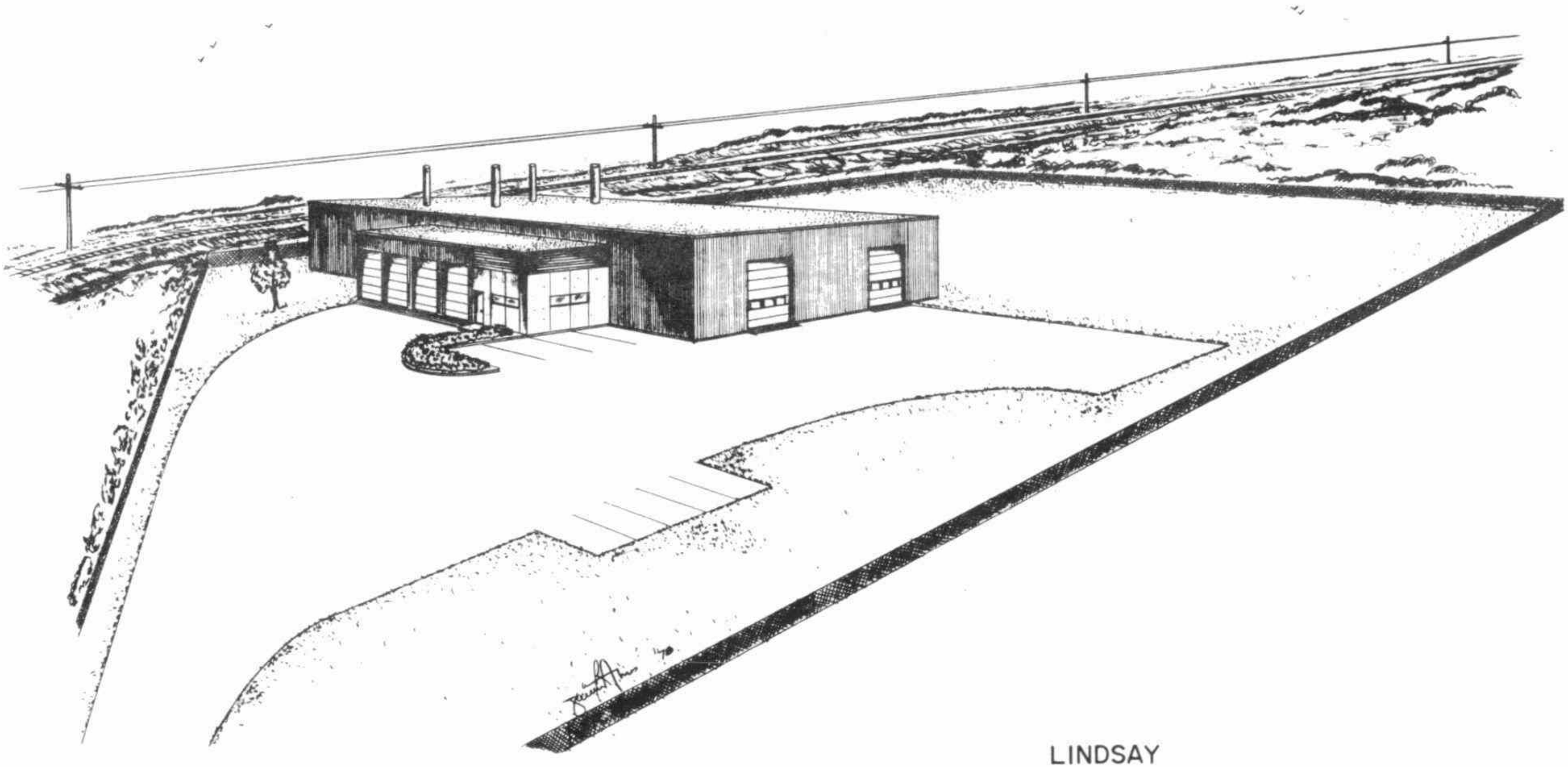


PLOT PLAN
SCALE: 1" = 100'

PLANT LAYOUT & PLOT PLAN
TOWN LANDS
(UNION CARBIDE)

the uma group

Exhibit 21



LINDSAY
ENERGY RECOVERY CENTRE

ESTIMATE SHEET

SPANTEC LIMITED
PROJECT MANAGERS

PROJECT Lindsay Exhibit 22.

SUBJECT Budget Estimate

SHEET ____ OF ____

DATE March 10, 1978 BY WEG

ITEM	DESCRIPTION	QUANTITY	RATE	MATERIAL	LABOUR	TOTAL
	SUMMARY					
1	Site Works					82,100
2	Concrete					109,700
3	Metals					128,500
4	Office Area					3,000
5	Plumbing					15,600
6	Ventilation					11,700
7	Electrical					46,500
8	Steam lines and condensate return					50,000
9	General requirements					126,870
	Sub-total: Base building					564,270
10	Equipment, including installation					1,128,865
11	Weighbridge					25,000
12	Bins					12,000
13	Overhead doors					10,000
14	Possible additional stack height					20,000
15	Duct for contaminated air from Union Carbide Plant					12,500
16	Engineering and supervision					50,000
17	Miscellaneous and contingency					37,500
						1,860,135

CHAPTER 5 - FINANCIAL ANALYSIS

5.1 SUMMARY OF THE ANALYSIS

This chapter outlines the financial analyses which were undertaken during the assessment of the energy recovery facility outlined in Chapter 4. Financial analyses are required in order to assess the overall economic viability of the project, and to determine the degree of financial support which might be required in order to provide project viability. In addition, the sensitivity of financial results to changes in major assumptions has been evaluated.

The operating requirements of the energy recovery facility outlined in Chapter 4 were established. These were employed to assess the possible operating costs of the facility. Based on refuse volumes and steam demand, estimates were made of the potential revenue to be derived from the sale of steam from the plant. The capital cost estimates of Chapter 4, repaid with interest over a reasonable amortization period, provided dept servicing requirements. These various cost and revenue elements were combined to provide an estimate of overall cash flow which would accrue to the operators of the project during the amortization period.

The financial impact of operating the proposed energy recovery plant was compared with the on-going cost of disposing of all refuse at the landfill site. This provided an estimate of the comparative economics of the existing system, and of the proposed energy recovery plant. Annual net cash flows were calculated, and were discounted to provide a base year net present value for comparative purposes.

5.2 ALTERNATIVES TESTED

A number of preliminary analyses were undertaken, in order to make a broad assessment of the financial viability of the energy recovery plant. In addition, this range of alternatives gave an indication of the variability of the financial results which might be expected under a range of assumptions.

The basic alternatives tested in preliminary analyses included the following:

- high and low energy prices, as outlined in the section entitled "Treatment of Inflation"
- high and low refuse volumes, with associated steam sales, as outlined in the section "Revenues"
- 10 and 15 year amortization periods, as outlined in the section "Capital Cost and Debt Service"
- steam price at full energy value, and at a discount of energy value as outlined in the section "Revenues"

Following the direction to the consultants to consider only the case of a scheme designed around Union Carbide, a number of refinements were made to both steam sales revenues and operating costs (in conjunction with Union Carbide). Financial analyses were then repeated for a restricted sub-set of alternatives.

Later analyses were all based on the shorter amortization period of ten years and with the steam price at full energy value.

5.3 REVENUES ACCRUING TO THE STEAM PLANT

Estimates of steam sales and associated revenues are dependent on projections of refuse tonnages which could be expected to be available to the plant. Based on the analyses of Chapter 1 of this report, two alternatives were considered for refuse tonnage. The optimistic projection is based on a volume of 16,750 tons in 1977. The pessimistic projection is based on 13,890 tons in 1977. In each case it was assumed that refuse tonnages would increase at 1¼% per year.

These refuse tonnages, when considered in conjunction with the pattern of demand from Union Carbide, form the basis of projected steam sales which are outlined below.

STEAM SALES VOLUMES
(Million Pounds Per Year)

YEAR	OPTIMISTIC REFUSE VOLUMES	PESSIMISTIC REFUSE VOLUMES
1980	134.1	104.5
1981	135.8	105.8
1982	137.5	107.1
1983	139.2	108.4
1984	141.0	109.8
1985	142.7	111.2
1986	143.4	112.6
1987	144.9	114.0
1988	146.4	115.4
1989	147.9	116.8
1990	149.4	118.3

It was assumed that the value of steam generated would be in the order of $2.45 per thousand pounds of steam. In earlier analyses, the possibility was considered that steam would be sold at a discount from its energy equivalent value. In later analyses, however, a more direct approach was used to estimate possible inefficiencies which would be borne by a purchaser of steam. The computed cost of these inefficiencies was included as an operating cost. Consequently, no discount from the energy value of the steam was employed.

The above estimates of steam volumes and steam prices provided the basis for estimated revenues for the energy recovery plant.

5.4 OPERATING COSTS

Labour cost estimates are based on the assumption of a 5-day week, coupled with a three-shift operation. The following complement is assumed:

- a second-class stationary engineer on day shift, and two third-class engineers on the other two shifts.
- the loader-driver for each shift.

- a clerk on the day shift only

Based on 1978 dollar estimates for wages and benefits, the total labour bill is approximately $133,000 a year for the operation of the plant.

In addition to labour costs, it was assumed that a $20,000 charge would be levied against the plant for administration costs.

Initial operating cost estimates include:

- auxiliary fuel: $1.00 per ton of refuse burned.
- electric power: considering both power usage and energy usage, cost of power is approximately $4,000 per year, plus approximately 6¢ for every 100 tons of refuse burned.
- maintenance costs: based on estimates from the manufacturer, it was assumed that maintenance costs would be $1.72 per ton of refuse burned.
- insurance: based on the assumption that the plant would be incorporated within a larger insurance policy, the estimated cost is approximately $2,000 per year.

An essential piece of operating equipment for the plant is a front-end loader. The loader is required both to undertake general housekeeping, and to charge the furnaces. The loader would be in operation virtually full time, and would require frequent replacement. It is estimated that a sum of $20,000 per year would cover operations and maintenance of the loader, and periodic replacement.

Costs of disposing ash from the incinerator have also been included in the operating cost estimates. Cost of trucking ash to the landfill site is estimated at $2.00 per yard of ash. 0.28 yards of ash are assumed to be generated per ton of refuse burned. In addition, it is estimated that it would cost $4,500 per year to receive the ash at the landfill site.

Two additional costs were also charged to the operating costs of the plant. These reflect the possible cost impact on a large steam user of hooking up with the energy recovery plan, and are based on discussions with

Union Carbide. These costs are:

- increased costs of operating the buyer's own steam plant, which are estimated to be \$89.50 per million pounds of steam.
- higher natural gas costs, due to reduced purchasing volumes, resulting as a charge of \$7,000 per year.

5.5 TREATMENT OF INFLATION

All revenues and operating costs are escalated to reflect anticipated future inflation. Two separate escalation factors were employed. Each revenue and cost item was broken into two portions; one portion would be expected to increase in price at the same rate as energy prices, while the other would increase in price at the same rate as labour costs. In all analyses, it was assumed that labour costs would increase at 6% per annum. Two alternative scenarios for energy prices were utilized. In the low energy price scenario, energy prices were also assumed to increase at 6% per annum. In the high energy price scenario, it was assumed that energy prices would increase at approximately 16½% per year until 1980, at which point the energy prices would escalate at 6% per year. These energy cost projections are based on data supplied by the Ministry of the Environment.

5.6 CAPITAL COST AND DEBT SERVICE

The capital cost of the plant delineated in Chapter 4 is estimated at \$1,860,000 in 1978 dollars. It was assumed that construction costs would escalate at 8% per year to 1980. Consequently, the 1980 dollar cost of building the plant would be \$2,170,000.

It was assumed that the debt service would reflect the amortization of the capital cost of the plant through equal blended payments at 10% per annum. Originally, amortization periods of both 10 and 15 years were studied. In later analyses, the more conservative period of 10 years was used. The operating life of the plant is expected to exceed 10 years, but the possibility of technological obsolescence makes it prudent to retain a short amortization period in the analysis.

5.7 COMPARISON WITH LAND FILL ALTERNATIVE

The overall profit or loss of the Lindsay plant was calculated based on revenues, operating costs, and debt service charges as described above. The overall financial position of the steam plant was compared with the cost of operating landfill operations on the present scale. Based on a review of the operating costs of the existing operation, it was estimated that it would cost approximately $84,000 per year in 1978 dollars, to continue with landfill disposal of all wastes. This cost was escalated over time on a basis of the escalators described above.

The cost of operating the landfill alternative was then compared with the projected financial position of the steam plant, in order to reflect the net impact on the Town of operating the energy recovery plant, rather than continuing to use landfill in the present manner.

5.8 RESULTS

The results of the financial analysis for two separate assumptions are presented as Exhibits 23 and 24. Under relatively optimistic assumptions regarding energy prices and refuse volumes, the energy recovery plant would operate at a loss throughout the 10-year amortization period. However, this loss would be decreasing, as the cost of the landfill alternative was escalating due to inflation. Consequently, towards the end of the operating period, the energy recovery plant would be less costly than the landfill alternative. Net difference between the two alternatives, when discounted to 1980 dollars with a 10% discount rate, amounts to approximately $400,000. This difference can be interpreted as the subsidy which would be required as a lump sum in 1980 to make the financial impact of operating the energy recovery plant equivalent to the impact of continuing with landfill during the 10-year horizon.

Under pessimistic assumptions regarding energy prices and refuse volumes, the cost of the steam plant would considerably exceed the cost of the landfill alternative throughout the whole 10-year amortization period. In this case, the present value of the net difference between the cost of operating the energy recovery plant, and the cost of operating the landfill, would be approximately $1,500,000 in 1980. This could again be interpreted as the lump sum subsidy which would be required in 1980 dollars to establish financial equality between the energy recovery plant and the landfill alternative.

It might be noted that heavy debt service costs are the major factors which reduce the overall profitability of the energy recovery plant. Consequently, any continued operation of the energy recovery plant after the 10-year amortization period could be expected to increase the attractiveness of the energy recovery alternative considerably. For the purposes of these evaluations, only conservative comparisons over the 10-year amortization horizon were employed.

5.9 FINANCING AND OWNERSHIP

There are a number of options available with respect to both the financing and ownership of the proposed energy recovery plant. A number of preliminary enquiries were made of various government agencies with respect to potential funding and financing arrangements. In addition, enquiries were made of various financial representatives regarding the impact of financing the energy recovery plant on Lindsay's overall finances.

It was clear from these enquiries that there was considerable scope for a range of ownership and financing alternatives. However, it was not possible to obtain definitive responses until detailed proposals were available. Consequently, these discussions are not reported upon in this chapter.

Exhibit 23

FINANCIAL ANALYSIS

REFUSE VOLUME - OPTIMISTIC
AMORTIZATION PERIOD - 10 YEARS
ENERGY PRICES - HIGH
STEAM ENERGY VALUE DISCOUNT - 0

AS VIEWED FROM TOWN PERSPECTIVE

DOLLAR AMOUNTS IN $000

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
STEAM SALES REVENUE	0	445	478	513	550	591	634	675	723	775	830
OPERATING COSTS											
LABOUR COSTS	0	150	159	168	178	189	201	213	225	239	253
ADMINISTRATION COSTS	0	22	24	25	27	28	30	32	34	36	38
MAINTENANCE COSTS	0	37	40	43	46	49	53	57	61	65	70
GROUNDS MAINTENANCE	0	6	7	7	7	8	8	9	9	10	10
AUXILIARY FUEL COSTS	0	24	25	27	29	31	34	36	39	42	45
HIGHER GAS RATE	0	9	10	11	11	12	13	13	14	15	16
ELECTRIC POWER COSTS	0	15	16	17	18	19	20	22	23	25	27
FRONT END LOADER	0	27	28	30	32	34	36	38	40	42	45
PROPERTY TAX	0	11	12	13	13	14	15	16	17	18	19
INSURANCE	0	2	2	3	3	3	3	3	3	4	4
ASH DISPOSAL	0	19	20	22	23	25	27	28	30	32	35
INCREASE COST TO BASE PLANT	0	16	17	19	20	22	23	25	26	28	30
TOTAL OPERATING COSTS	0	339	360	383	408	434	462	491	523	556	592
NET OPERATING POSITION	0	106	117	129	142	157	172	184	201	218	238
DEBT SERVICE	0	353	353	353	353	353	353	353	353	353	353
OVERALL PROFIT/(LOSS)	0	(247)	(236)	(224)	(211)	(196)	(181)	(169)	(153)	(135)	(115)
COMPARISON WITH LANDFILL ALTERNATIVE											
PROFIT/(LOSS) OF STEAM PLANT	0	(247)	(236)	(224)	(211)	(196)	(181)	(169)	(153)	(135)	(115)
LANDFILL COST	0	(107)	(114)	(121)	(128)	(136)	(144)	(152)	(162)	(171)	(181)
DIFFERENCE	0	(139)	(122)	(103)	(83)	(61)	(37)	(17)	9	36	66
CUMULATIVE DIFFERENCE	0	(139)	(261)	(364)	(447)	(508)	(545)	(562)	(553)	(517)	(451)
PRESENT VALUE	(384)										
BASE DATA											
REFUSE TONNAGE	0	17400	17617	17838	18061	18286	18515	18746	18981	19218	19458
LABOUR ESCALATOR	.000	1.124	1.191	1.263	1.339	1.419	1.504	1.594	1.690	1.791	1.899
ENERGY ESCALATOR	.000	1.355	1.436	1.522	1.614	1.711	1.813	1.922	2.037	2.160	2.289
STEAM SALES VOLUME	.00	134.10	135.80	137.50	139.20	141.00	142.70	143.40	144.90	146.40	147.90
STEAM PRICE	.00	3.32	3.52	3.73	3.95	4.19	4.44	4.71	4.99	5.29	5.61

Exhibit 24

FINANCIAL ANALYSIS

REFUSE VOLUME - PESSIMISTIC
AMORTIZATION PERIOD - 10 YEARS
ENERGY PRICES - LOW
STEAM ENERGY VALUE DISCOUNT - 0

AS VIEWED FROM TOWN PERSPECTIVE

DOLLAR AMOUNTS IN $000

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
STEAM SALES REVENUE	0	288	309	331	356	382	410	440	472	507	543
OPERATING COSTS											
LABOUR COSTS	0	150	159	168	178	189	201	213	225	239	253
ADMINISTRATION COSTS	0	22	24	25	27	28	30	32	34	36	38
MAINTENANCE COSTS	0	28	30	32	34	37	40	43	46	49	53
GROUNDS MAINTENANCE	0	6	6	6	7	7	8	8	8	9	9
AUXILIARY FUEL COSTS	0	16	17	19	20	21	23	25	27	28	31
HIGHER GAS RATE	0	8	8	9	9	10	11	11	12	13	13
ELECTRIC POWER COSTS	0	11	12	12	13	14	15	16	17	18	20
FRONT END LOADER	0	22	24	25	27	28	30	32	34	36	38
PROPERTY TAX	0	11	12	13	13	14	15	16	17	18	19
INSURANCE	0	2	2	3	3	3	3	3	3	4	4
ASH DISPOSAL	0	14	15	16	17	18	20	21	22	24	26
INCREASE COST TO BASE PLANT	0	11	11	12	13	14	15	16	17	19	20
TOTAL OPERATING COSTS	0	301	320	341	362	385	409	435	463	492	523
NET OPERATING POSITION	0	(14)	(12)	(9)	(7)	(3)	1	5	9	15	20
DEBT SERVICE	0	353	353	353	353	353	353	353	353	353	353
OVERALL PROFIT/(LOSS)	0	(367)	(365)	(362)	(360)	(356)	(353)	(348)	(344)	(339)	(333)
COMPARISON WITH LANDFILL ALTERNATIVE											
PROFIT/(LOSS) OF STEAM PLANT	0	(367)	(365)	(362)	(360)	(356)	(353)	(348)	(344)	(339)	(333)
LANDFILL COST	0	(94)	(100)	(106)	(112)	(119)	(126)	(134)	(142)	(150)	(160)
DIFFERENCE	0	(272)	(265)	(256)	(247)	(237)	(226)	(215)	(202)	(188)	(173)
CUMULATIVE DIFFERENCE	0	(272)	(537)	(793)	(1040)	(1278)	(1504)	(1718)	(1920)	(2108)	(2282)
PRESENT VALUE	(1453)										
BASE DATA											
REFUSE TONNAGE	0	14400	14580	14762	14947	15134	15323	15514	15708	15905	16103
LABOUR ESCALATOR	.000	1.124	1.191	1.263	1.339	1.419	1.504	1.594	1.690	1.791	1.899
ENERGY ESCALATOR	.000	1.124	1.191	1.263	1.339	1.419	1.504	1.594	1.690	1.791	1.899
STEAM SALES VOLUME	.00	104.50	105.80	107.10	108.40	109.80	111.20	112.60	114.00	115.40	116.80
STEAM PRICE	.00	2.75	2.92	3.09	3.28	3.48	3.67	3.91	4.14	4.39	4.65

CHAPTER 6 - CONCLUSIONS AND RECOMMENDATIONS

If the project is to be judged by strictly commercial considerations, it is not possible to recommend that it proceeds. Although a reasonable market exists for the steam generated (in terms of matching the supply and demand), the revenue from the sale of this steam does not cover total costs, even in the most optimistic cases of high energy replacement prices and maximum energy supply from garbage. This overall loss is in all cases greater than the "loss" which the Town would incur by tipping the garbage in a landfill site. Thus the difference between the two methods represents an additional "loss" to the Town. However, this additional "loss" can also be regarded as the premium which society would have to pay in order to dispose of its garbage by other than the landfill method. The amount of this premium can be expressed as a one-time front-end cost by calculating the present value of the stream of additional "losses" to the Town.

The financial analysis shows that the amount of this premium can vary quite widely- between $0.4 million and $1.5 million - depending on what happens in the future to energy prices and supply of garbage. Energy prices have a direct impact on the revenue that can be attributed to the sale of steam. The supply of garbage has a direct impact on the supply of unconverted energy to the plant; if the market for waste paper/cardboard for recycling purposes becomes strong and permanent, the scheme loses both a good source of energy and a source of tipping fees: on both counts, the losses increase. These factors are outside the control of the Town.

It should be pointed out that the scheme will generally pay to the extent of covering the operating costs. The extent of the loss is therefore governed by the period over which it is decided to write off the plant and this has been reflected in the debt service charge. The losses could be reduced by using a longer write-off period. However, the period of ten years appears to be a prudent choice. Similar plants elsewhere have not been in operation long enough to assure the Town that a longer productive life can be relied upon, although it must be emphasized that there is no reason to suppose that these plants have a productive life of only ten years. Until further experience is gained, it is perhaps unwise for towns of the size of Lindsay to run the risk of finding themselves, a few years down the road, owning a plant which has ceased to be productive but which still has book value.

Another element of risk lies in the future continuity of the market for steam. It is the nature of a steam generating plant that it has to be tied permanently to the user. With any commercial customer for steam, as opposed to, say, the Ross Memorial Hospital, there is some chance that in the future the company may cease to be a customer for steam. If this happens before the plant has been written off, then the Town and/or the Province is faced with paying for the remaining book value without any offsetting revenue. Until agreements are negotiated, it is not possible to say how much risk this represents. The Town has two possible fallback positions. One is to locate the plant on such a site that it would be reasonably practical to hook up the steam generator to another steam user. The second fallback position is to consider adding a steam turbine/electricity generator to the system and selling the electrical power to the Lindsay Hydro-Electric system. Both of these fallback positions are technically feasible, but neither provides complete financial protection.

The Town of Lindsay has submitted a request to the Province of Ontario (through the Ministry of the Environment) for financial assistance. Maximum assistance by the Province will be required in the case in which the Province takes all of the risk, and this report is therefore orientated to evaluating what this maximum assistance might be. The Province has stated that its policy is to provide one-time financing, rather than an on-going subsidization of losses every year. Assistance might, therefore, take the form of a one-time grant to the Town which will be large enough to fund the stream of losses assuming the worst happens; at the end of an agreed period(s), there would be an accounting of what has happened, and the Town would refund to the Province the excess by which actual performance exceeded the worst case.

The losses could require funding of up to $1.5 million. However, this will not be sufficient to construct the plant, which has been shown elsewhere to be estimated at nearly $2.2 million in 1980 dollars, and it it this larger figure that will be needed to get the scheme off the ground. The difference between this figure and the upper grant figure of $1.5 million is accounted for notionally by the tipping fees which the Town would still collect if a landfill operation were in progress but which would no longer be needed to pay for the landfill operation. These tipping fees would flow back to the Province in repayment of the difference.

The above amounts are subject to further refinement. In particular, they will not be finally known until

- the operator of the stean plant and his operating relationship with the steam user are decided. This will affect the type and cost of the instrumentation and controls that have to be provided.
- the plant is tendered.
- the terms of the agreements (including interest rates) between the Province and the Town and between the Town and the steam user (Union Carbide) are finalized.

Further, it appears that neither the Province nor private sources of funds will make definite commitments until the numbers are finalized and involvements can be defined. Consequently, it is recommended that there should be a further stage of study, whose goal is final definition of Provincial, Town, and Union Carbide involvements, signing of the above agreements, and the start of construction. During this stage, the following activities will take place:

- the operator of the plant will apply for an Environmental Assessment hearing and obtain approval to construct the plant.
- final engineering of the plant, including instrumentation and controls and tie-ins to the steam user, will be done.
- Tenders for the construction of the plant will be called.
- the terms of the above agreements will be negotiated and finalized.

It is recommended that terms of reference for this Stage II are drawn up and that funding for it be provided.

APPENDICES

Appendix 1 - Sheet 1

QUANTITY OF SOLID WASTE - WEEK OF NOV. 17 - DEC. 3/77

(In Tons)

ORIGIN	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	TOTAL
Residential	16.435	18.565	3.605	13.405	14.68		66.69
Abex	3.110	1.940	1.455	.605	5.325		12.435
Armstrong	3.200		4.675		4.815		12.690
Canada Crayon				6.365			6.365
Deyell		3.975	3.835	3.475	2.68		13.965
Lindsay Paper Box					2.960		2.960
Loblaws					5.10		5.10
Prowler	4.510	4.035	3.445	1.205			13.195
Rosedale Plastics			.910				.910
Trent Rubber	3.930				5.30		9.23
Union Carbide	5.748			1.42	7.695		14.863
Uniroyal	.415		.049				.464
Construction Waste	2.310		7.125		15.010		24.445
Misc.Ind. & Comm.	9.352	20.985	14.10	21.375	15.055	6.215	87.082
Cars, Trucks, Etc. @ 150 Lbs. Each	1.650	2.40	2.175	1.275	2.625	4.800	14.925
	50.66	51.900	41.374	49.125	81.245	11.015	285.319

Appendix 2 - Sheet 2

QUANTITY OF SOLID WASTE - WEEK OF DEC. 4 - DEC. 10/77

(In Tons)

ORIGIN	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	TOTAL
Residential	15.28	15.70	.935	12.59	14.44		59.645
Abex	1.52		.66	2.11	4.365		8.655
Armstrong	1.85		4.925		5.165		11.94
Canada Crayon							------
Deyell		2.89	2.59		3.565		9.045
Lindsay Paper Box					2.875		2.875
Loblaws					4.165		4.165
Prowler	5.61	3.09	3.225	4.33			16.255
Trent Rubber				1.80			1.80
Union Carbide	4.07	4.015		4.14	9.985		22.21
Uniroyal			.915				.915
Construction		2.45	1.54		3.635		7.625
Misc.Ind.& Comm.	20.23	19.555	16.00	16.47	30.325	2.725	105.305
Cars,Pickups,Trailers @150 lbs. each	2.625	.75	1.20	1.50	.9	1.575	8.55
TOTAL:	51.885	48.45	31.99	42.94	75.785	7.935	258.985

Appendix 1 - Sheet 3

QUANTITY OF SOLID WASTE - WEEK OF DEC. 11 - DEC.17/77

(In Tons)

ORIGIN	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	TOTAL
Residential	15.430	20.385	1.325	8.690	11.43		57.26
Abex		1.985	2.665	3.875	9.39		17.915
Armstrong	.130		4.11	1.145	3.86		9.245
Canada Crayon	7.04						7.04
Deyell		4.52		3.89	3.655		12.065
Lindsay Paper Box						2.075	2.075
Loblaws					4.10		4.10
Prowler	1.25	4.515	4.230	5.08			15.075
Rosedale Plastics							
Trent Rubber		4.015	2.47				6.485
Union Carbide	1.745	2.21	3.585	7.30	1.135		15.975
Uniroyal		1.555		2.505			4.060
Construction Waste	8.18	3.60					11.78
Misc.Ind. &Comm.	16.365	14.39	19.17	16.495	30.895	1.16	98.475
Cars,Trucks,etc.@150 lbs.each.	1.425	1.275	1.05	1.575	2.325	3.225	10.875
TOTAL:	51.565	58.450	38.605	50.555	66.79	6.46	272.425

Appendix II

WEEKLY REVENUES FOR DUMPING OF COMMERCIAL AND INDUSTRIAL WASTE

LINDSAY LANDFILL SITE W/E APR.8-DEC.17/77

WEEK ENDING	REVENUE
April 9	1,272.00
April 16	1,705.00
April 23	1,654.50
April 30	1,655.75
May 7	1,709.00
May 14	1,769.00
May 21	1,872.00
May 28	1,462.00
June 4	1,591.00
June 11	1,565.00
June 18	1,594.00
June 25	1,657.00
July 2	1,288.00
July 9	1,514.00
July 16	1,336.00
July 23	1,235.00
July 30	1,352.00
August 6	1,096.00
August 13	1,315.00
August 20	1,388.00
August 27	1,454.00
September 3	1,510.00
September 10	1,254.00
September 17	1,341.00
September 24	1,473.00
October 1	1,267.00
October 8	1,391.00
October 15	1,106.00
October 22	1,375.00
October 29	1,507.00
November 5	1,239.00
November 12	1,317.00
November 19	1,216.50
November 26	1,262.00
December 3	1,177.50
December 10	1,142.50
December 17	1,133.00

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Final report : feasibility of
recovering energy from
municipal waste in the town of
Lindsay.

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